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NOVEMBER 5, 1976

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EDN

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Test your data acquisition IQ

Design rules differ for chokes and inductors

Tracking generators help "hurdle" spectrum analyzer measurement problems



REQUALIFICATION ISSUE
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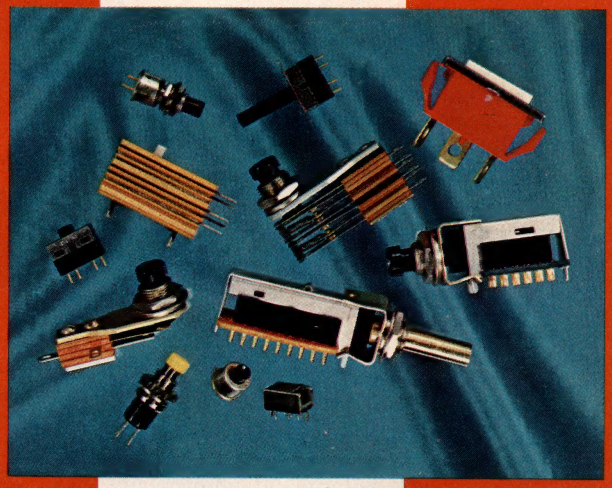
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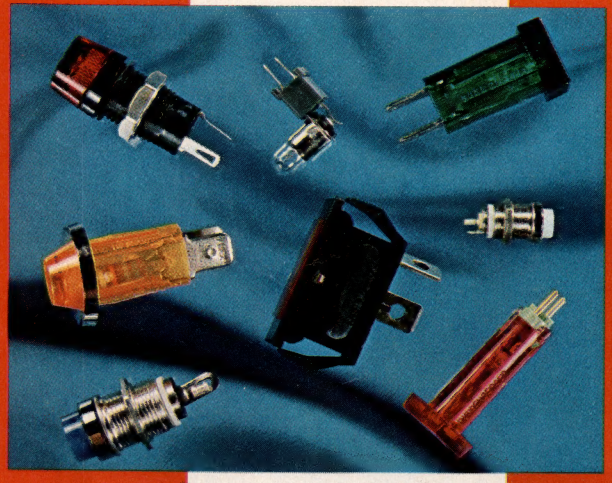
CHICAGO SWITCH



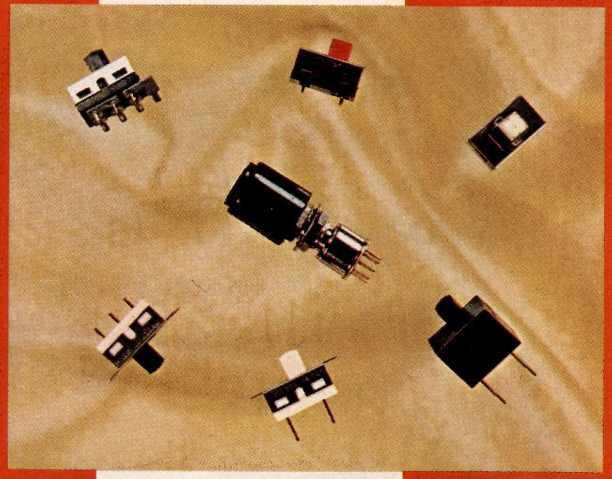
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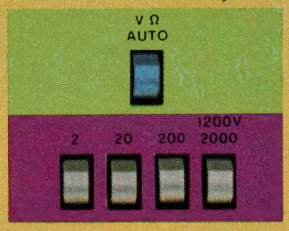
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Hewlett-Packard's new 3435A 3½ digit, five function digital multimeter, with full one-year accuracy specifications, is the right decision for your general purpose bench or field needs because it has . . .

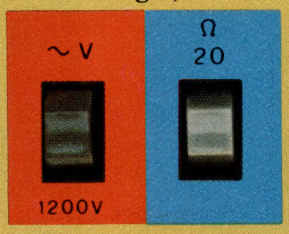
Autoranging and manual modes: AC voltage, DC voltage and resistance can be measured either on autorange or manually selected ranges. Select autorange to speed readings and minimize reading error . . . the LED readout always displays appropriate units. For repetitive readings, or AC and DC current measurements, use the manual mode, selecting from at least five ranges for each function . . . again the appropriate units will be automatically displayed.

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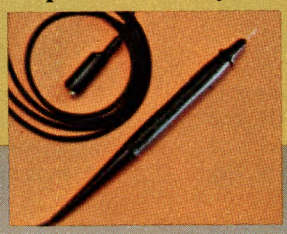
Autoranging and manual modes,



Wide measurement ranges,



And touch-hold probe accessory.



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096/45



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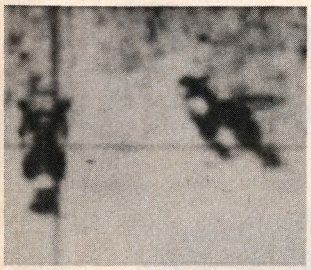
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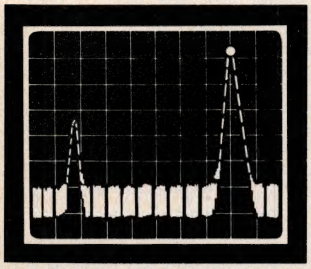
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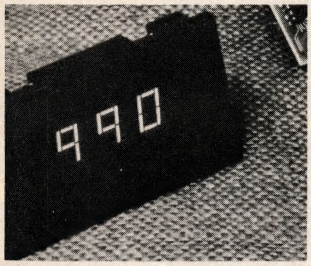
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



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COVER

Our photo from Hewlett-Packard takes some literary license to illustrate how tracking generators can considerably extend the capabilities of spectrum analyzers. The related article begins on pg. 38.

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Sonar detects Lock Ness "monsters" and ancient ruins 21

Laser scanning "looks" inside active semiconductor devices and safely reveals their functioning . . . Copper foot will put the "finger" on footwear heat-loss problems.

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µP digs signals out of a very noisy environment — outer space! . . . 8080 points to faulty memory chips in mainframe add-on memory system.

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Tracking generators stretch spectrum-analyzer capabilities 38

Whether built-in, plug-in or stand-alone, the tracking generator makes spectrum analysis easier while increasing accuracy.

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Linear-inductor design emphasizes inductance stability; but design for power-supply filter chokes may call for variable inductance.

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Tradition reigns supreme in the less exotic areas of electronics, so any design breakthrough really is significant!

Designer's Guide to: Physical design and packaging — Part 3. 75

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Presenting: The answers to our quiz on DAS modules 83

By studying our explanations, you should be well prepared to apply these versatile data-acquisition system building blocks.

DESIGN AWARDS. 86

Let "Power-ON" generate a noise-free transition pulse . . . Improved PUT oscillator operates over a wide range . . . Data collector selectively multiplexes inputs . . . Suppressed-carrier demodulator uses two active devices.

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DPM uses I^2L to shrink parts count, size, power and cost 92

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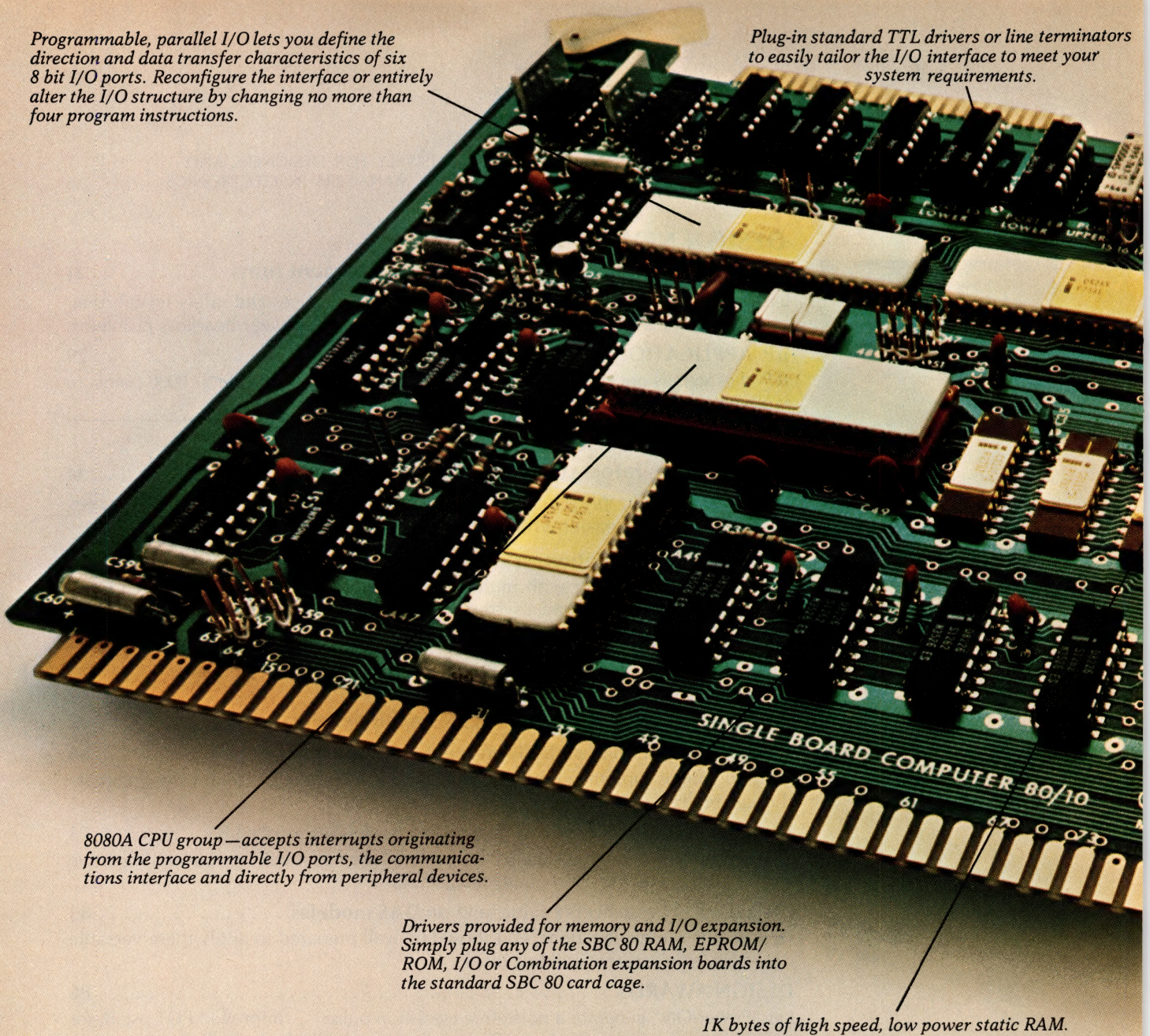
DESIGN DEPARTMENTS

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Requalification Card 1A-1B

BPA ☆ABP

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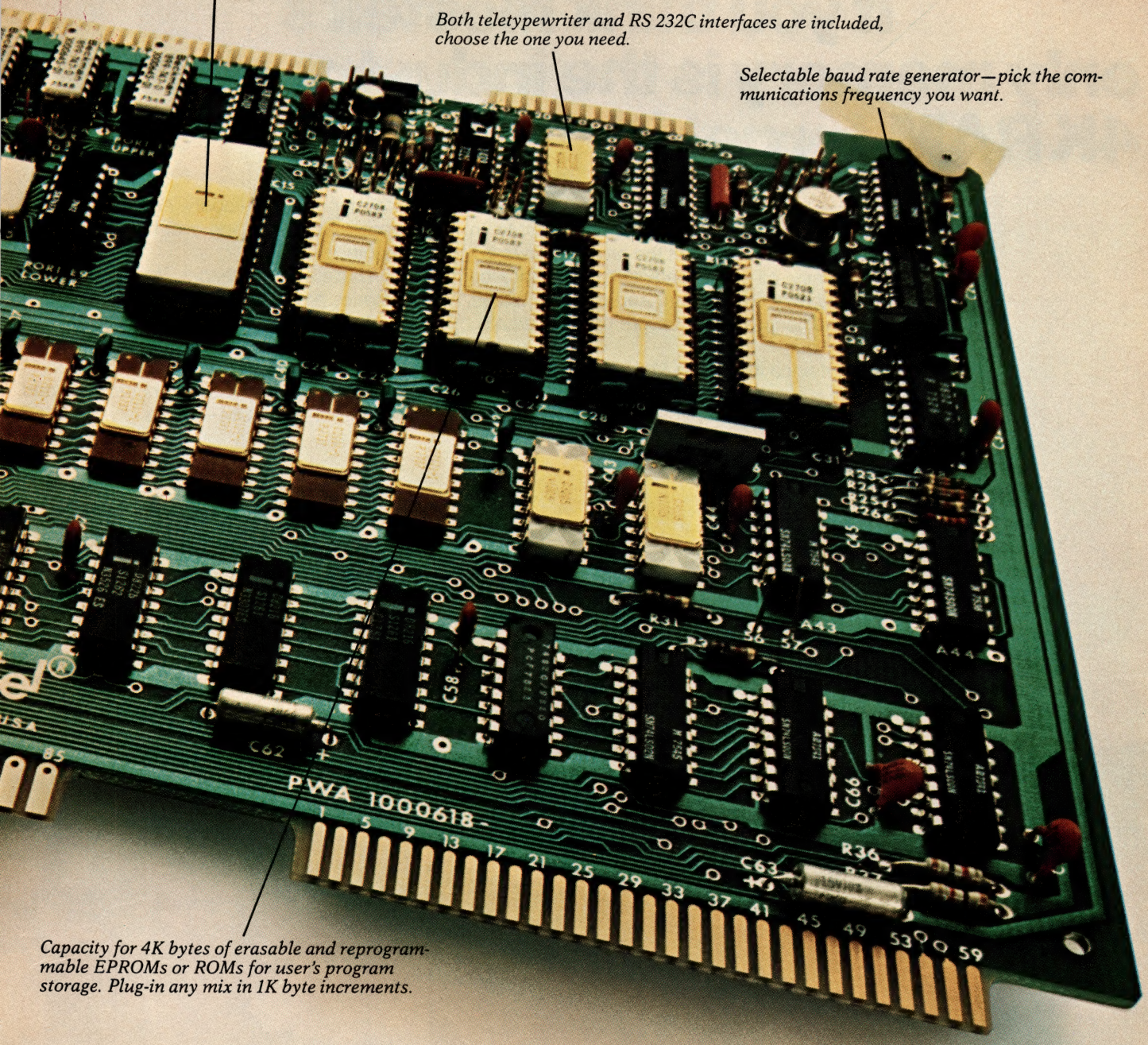
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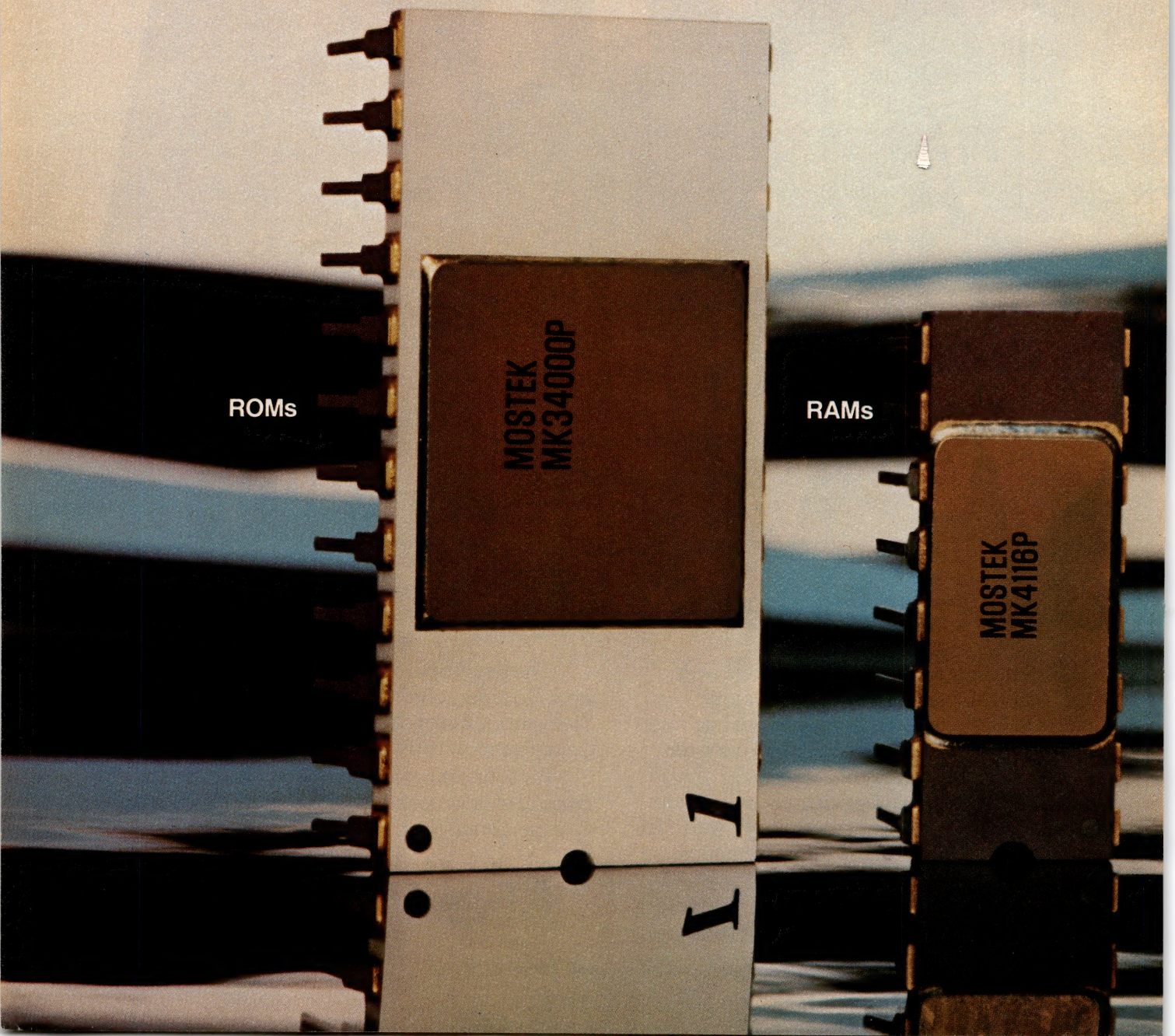
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Description	Part No.	Access Time
1K Dynamic	MK 4006P—6	400ns
	MK 4008P—6	500ns
256-Bit Static	MK 4007P(N)	525ns
	MK 4007P—4(N)	525ns
1K Static	MK 4102P	1μs
	MK 4102P—1	450ns
	MK 4102P—6	275ns
	MK 4102P—8	250ns
4K Dynamic	MK 4096P—6(N)	250ns
	MK 4096P—11(N)	350ns
	MK 4096P—15(N)	350ns
	MK 4096P—16(N)	350ns
	MK 4200P—11(N)	350ns
	MK 4200P—16(N)	300ns
	MK 4027P—2	150ns
	MK 4027P—3	200ns
	MK 4027P—4	250ns
4K Static	MK 4104P*	200ns
16K Dynamic	MK 4116P—2	150ns
	MK 4116P—3	200ns

Read Only Memories

2K ROM	MK 2400P	550ns
4K ROM	MK 2500/2600P	400ns
8K ROM	MK 30000P	450ns
16K ROM	MK 28000P(N)	600ns
	MK 31000P	550ns
	MK 34000P	350ns

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	MK 3702T—2	750ns
	MK 3702T—3	1μs
8K EPROM	MK 3708T*	450ns

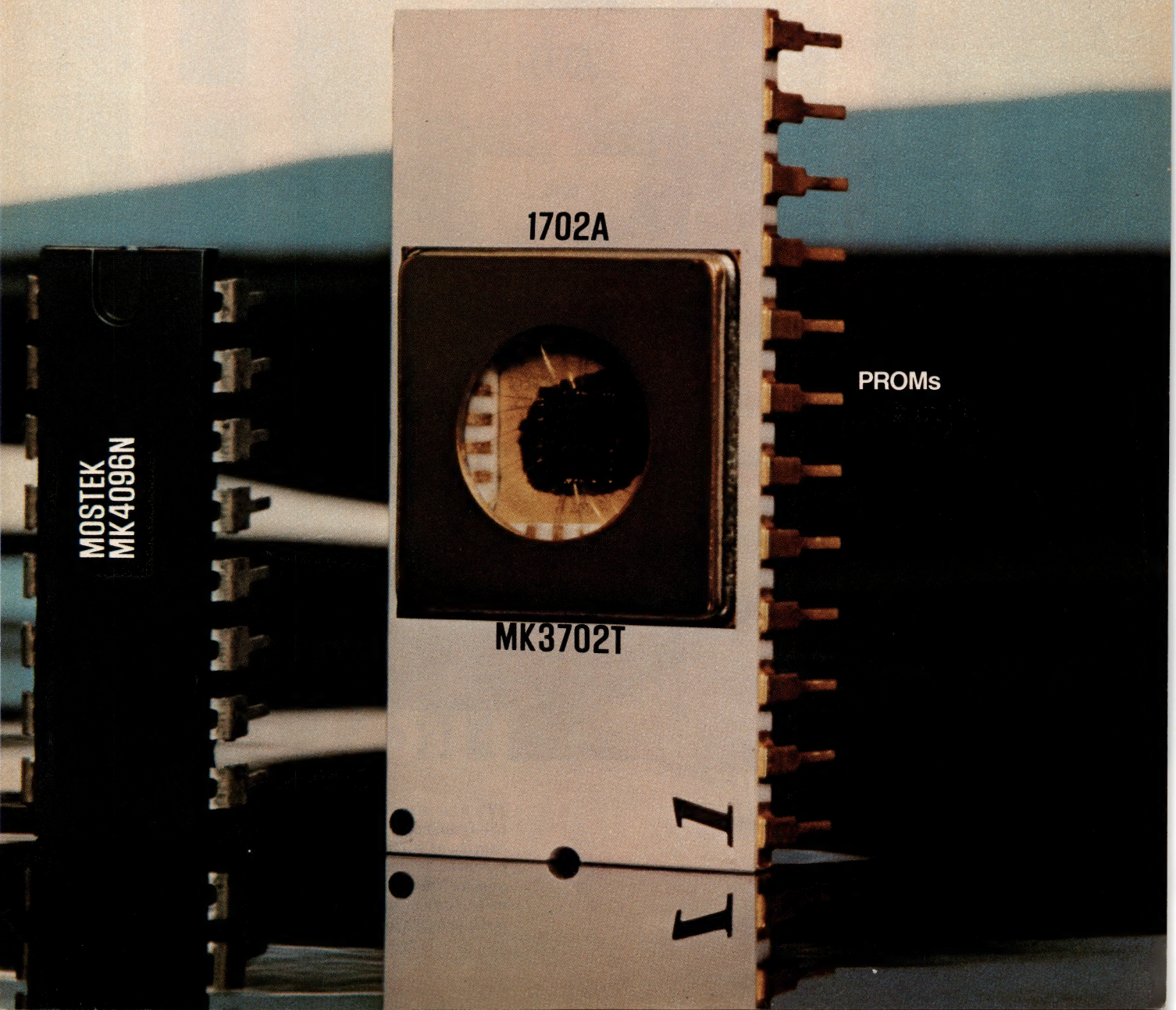
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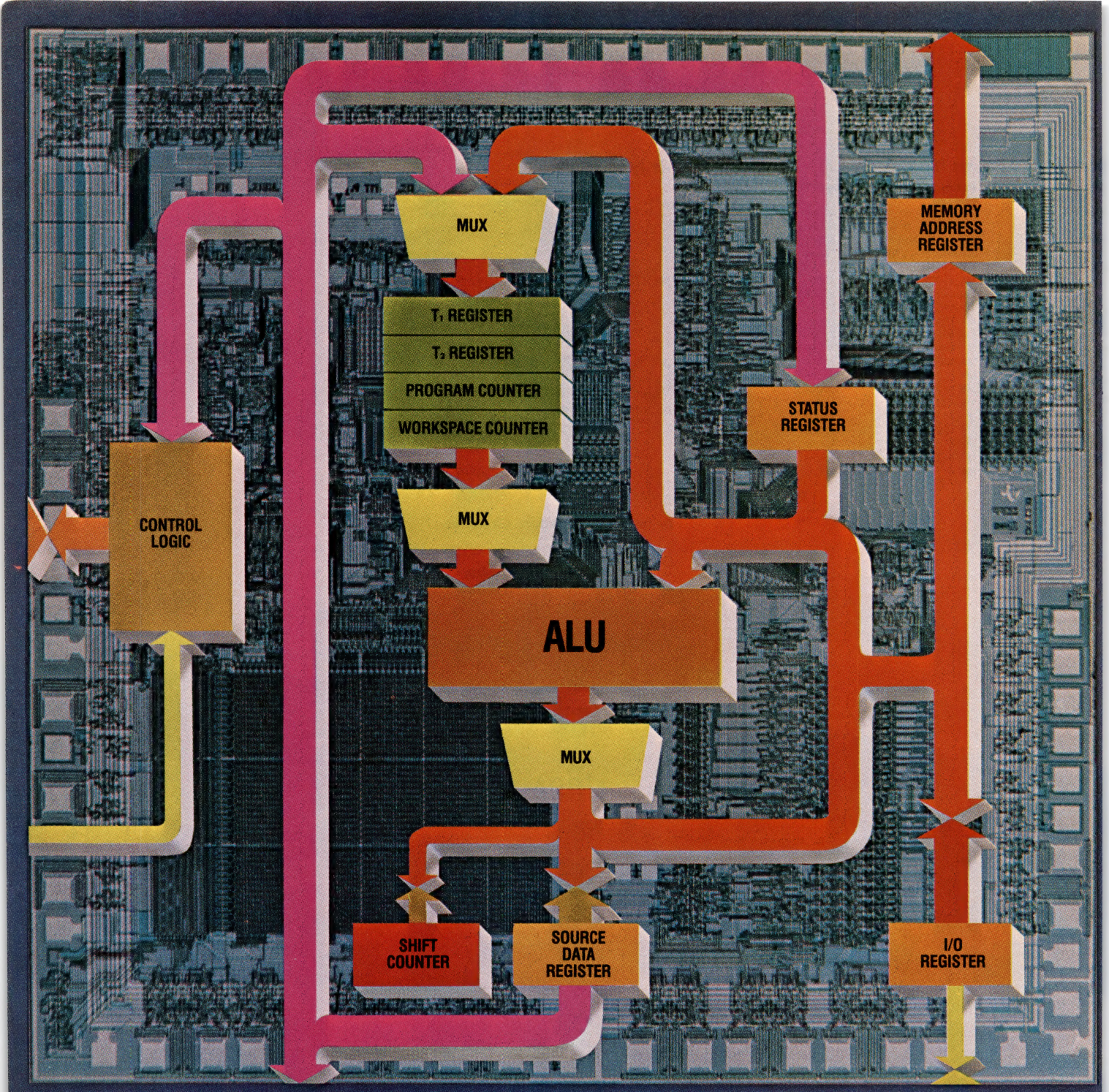
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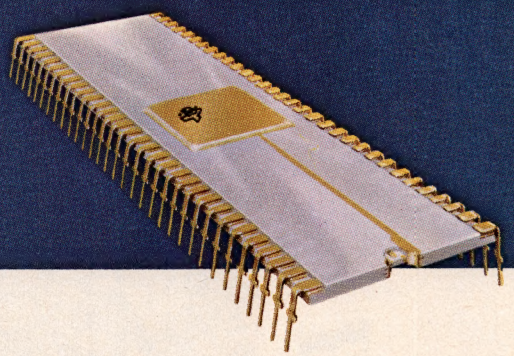
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These benefits stem from the TMS9900's advanced features:

16-bit instruction word with full 16-bit data precision.

Operation at 3.3 MHz clock rate.

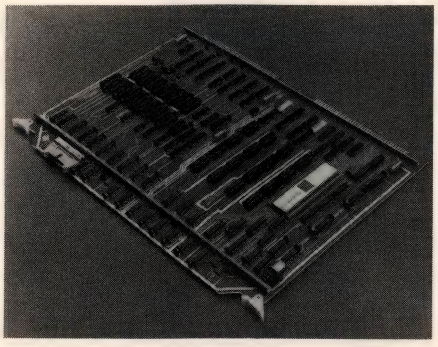
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990/4 Board System

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990/4 Prototyping System

More 9900 Family Soon
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SIGNALS and NOISE

Who needs the BET degree?

My August 5, 1976 editorial, which discussed the establishment of a formal qualification procedure for the practice of electronic engineering, generated a flood of reader responses. Obviously, my ideas are quite controversial, as evidenced by the following thought-provoking replies.
Walt Patstone
Editor

"Forget about degrees..."

Dear Mr. Patstone,
After reading your August 5th editorial on the "sub-professional," I thank you for assuring me 100% that EE's have a complete lack of reasoning power. In the cloud (9?) of all your professionalism, allow me to remind you it is the individual that makes contributions to society—not professionalism!

We should measure men against men, not men against degrees. The creative engineer, in my mind, defines the problem, then dives in head first to solve it. My definition makes no mention of where he was educated, what he earned there, or how well he did. Let's all be friends and work together; forget about degrees, professionalism, and politics.

R. L. Wuorenma
Cutler-Hammer
Milwaukee, WI

Interesting questions!

Dear Mr. Patstone,
Your August 5th editorial makes me wonder...

Is licensing (legalizing) intended to upgrade the quality of work performed, or restrict the quantity of people doing the work? Will a license necessarily imply integrity? In what fields has licensing upgraded innovativeness? Will a license enable a person to stand on his credentials instead of his capability? Who will licensing serve? (The incompetent licensees? The competent nonlicensees? The public?) Would the public be better served by an open engineering market—or by a legal institution more concerned with its own survival than problem solving? What about specialty licenses or licenses for staying current?

Thanks for making me wonder!
Phil Pinel
Manning Environmental
Santa Cruz, CA

Inexpensive doesn't have to mean cheap.



At $31*, the VIP Compact 1 enclosure is very economical. But it has a lot of the design features you usually find on much more expensive models. And it has one standard feature that sets it apart from all other low priced enclosures.

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Let's avoid bureaucracies

Dear Mr. Patstone,

While we agree wholeheartedly that the qualifications and competence of EE's should meet the highest possible standards, we would like you to explain how a licensing bureaucracy established by government could possibly evaluate a potential engineer better than the prospective employer, who will suffer the consequences of a bad choice.

Provided you can find some rationale, you must still consider the political power in the hands of the licensing bureaucrat. Most likely he has some political axe to grind, and who will be the casualties? How does that influence the freedom of the press concerning engineers?

Do you think we should license electronics magazines to assure quality?

Bill Olschewski, Jim Naylor
and *Larry McDonald*
Design Engineers
Burr-Brown
Tuscon, AZ



A basis in theory

Dear Mr. Patstone,

Present-day EE's, with the possible exception of "HAMS," generally don't speak the same language as technicians. Fine with esoteric theory (some of which isn't compatible with real-world applications, like the Hilbert theory that single-sideband transmission won't lead to power economy), some EE's can't reduce even valid theory to practical circuits in many cases. And much "theory" proves totally invalid only because a fundamental limitation is overlooked.

Education MUST have an adequate basis in fundamental theory, or engineering becomes an esoteric science. Why else do so many outstanding achievers in EE have both a strong physics background and a deep insight into practical aspects of electronic devices and circuits?

Keats A. Pullen, Jr.
Kingsville, MD

How many ITT Components Group PZSM PCB relays can fit on the head of a single Potter & Brumfield T10?



☐ Three ☐ Five
☐ Four ☐ Six

Six PZSM relays from ITT Components Group can fit on the head of one Potter & Brumfield T10. Yes, six. When it comes to designing low-profile PCB relays for low-level communications switching applications, ITT knows the value of real estate. Reliability, speed, low cost, and long-life expectancy . . . four designed-in features that help make the PZSM a better alternative to the over-sized, over-powered relay you may be using now.

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	ITT/PZSM	ITT/RZ	ITT/LZ	ITT/MZ	P&B/T10
SIZE					
Height	0.36 in.	0.43 in.	0.56 in.	0.39 in.	0.37 in.
PCB Space	0.29 in.²	0.30 in.²	0.52 in.²	0.25 in.²	1.78 in.²
CONTACTS					
Load	0.5A	1A	3A	1A	3A
Form	2C twin	2C crossbar	1C	1C	2C twin
Material	Au-Ag alloy	Ag	Ag	Au-Ag	Au flash Ag
COIL					
Voltages	5-6-12-24	4.5-6-12-24	5-6-9-12-24-48	1.5-3-5-6-9-12-24	6-12-24-48
Average Power	170mW	525mW	330-450mW	450mW	300mW
LIFE					
Mechanical	200 x 10⁶	100 x 10⁶	20 x 10⁶	10 x 10⁶	100 x 10⁶
Electrical	1 x 10⁶	1 x 10⁶	0.5 x 10⁶	0.5 x 10⁶	1 x 10⁶
COST					
1K Pieces	$2.50	$1.85	$1.20	$1.10	$2.60*

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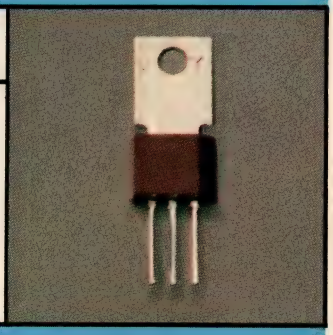
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GE TYPE	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	h_{FE} @5V, 200 mA MIN.	h_{FE} @5V, 200 mA MAX.
D40C1	6.25	30	10,000	60,000
D40C2	6.25	30	40,000	—
D40C3	6.25	30	90,000	—
D40C4	6.25	40	10,000	60,000
D40C5	6.25	40	40,000	—
D40C7	6.25	50	10,000	60,000
D40C8	6.25	50	40,000	—

COMMENTS

- **Very High Gain** – 60k typical; High input impedance – 50k ohm typ; 1.2 watts P_T @ 25°C ambient.
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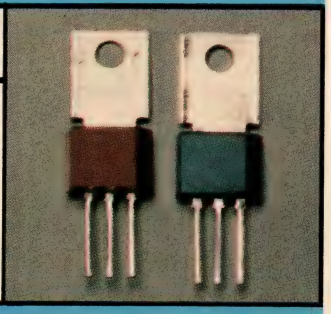


COMPLEMENTARY — 2 AMPERES

GE TYPE NPN	GE TYPE PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	h_{FE} @5V, 200 mA MIN.
D40K1	—	10	30	10,000
—	D41K1	10	−30	10,000
D40K2	—	10	50	10,000
—	D41K2	10	−50	10,000
—	D41K3	10	−30	10,000
—	D41K4	10	−50	10,000

COMMENTS

Typical Applications:
- IC Interface
- Driver
- Regulator
- Touch Switch
- Lamp Driver
- Audio Output
- Relay Substitute
- Servo-Amplifier
- TO-202 Package

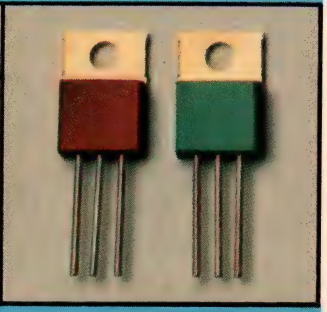


COMPLEMENTARY — 10 AMPERES

GE TYPE NPN	GE TYPE PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	h_{FE} @5V, 5 Amps MIN.
D44E1	—	50	40	1000
—	D45E1	50	−40	1000
D44E2	—	50	60	1000
—	D45E2	50	−60	1000
D44E3	—	50	80	1000
—	D45E3	50	−80	1000

COMMENTS

Typical Applications:
- IC Interface
- Relay and Solenoid Driver
- Regulator
- Inverter Power Supply Switch
- Audio Output
- Relay Substitute
- Oscillator
- Servo-Amplifier
- TO-220AB Package



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GENERAL ELECTRIC

New: tone receiver hybrids from Beckman.



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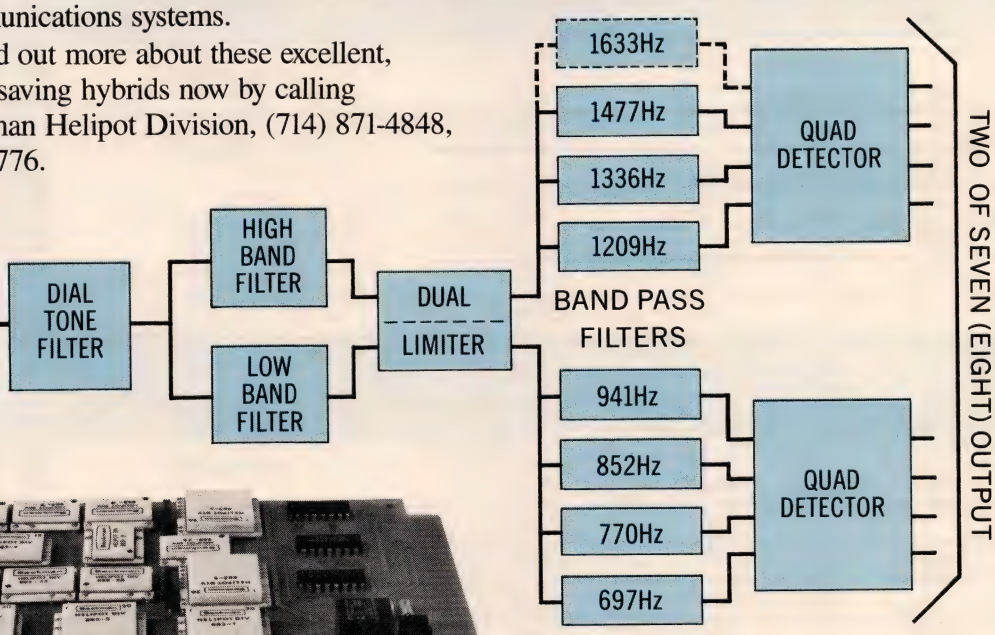
Beckman Series 883 Telephone Tone Receiver Hybrids, available off-the-shelf as individual modules or as preassembled systems.

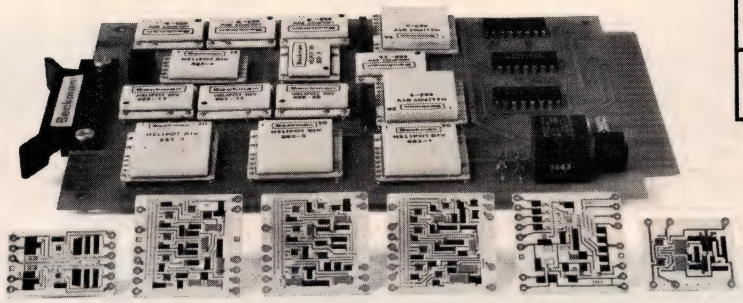
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EDITORIAL



What this industry needs is a good $100 computer peripheral

Competent marketing people tell me to expect no major breakthroughs in low-cost printers, CRT terminals and mass memories. They say the technologies are mature. Fortunately, most innovations come from engineers, not marketers. Thus, these key computer-system elements are not predestined for stagnation, after all.

Rapidly decreasing prices for μP and support chips have relegated the "heart" of any microcomputer system to a most elementary role in determining overall costs. Therefore, if electronics is to make greater headway into price-sensitive consumer and light-industrial applications, costs of interface and storage devices must come down as well. The need is obvious and overwhelming.

We don't need products with state-of-the-art performance at unrealistically low prices. Rather, these products must offer only moderate performance, reasonable reliability and price tags significantly lower than existing offerings.

Clearly the problem cries for innovative design approaches, not cost-reduction campaigns on current designs. Further, it demands a careful determination of the end user's requirements, as well as his ability and willingness to pay.

For many of you this situation represents an unprecedented opportunity. New companies founded by engineers can get a head start on the low-cost computer-peripheral market and become instant successes. At the same time, designers in established companies who can create a product right on target and convince management to go all the way with it can greatly enhance their careers and their firms' market positions.

Will you accept this challenge? Why not brainstorm the subject with your colleagues? Suggest solutions with complete abandon, no matter how unconventional they seem. If one or more look promising, do your homework, then present your case to the proper individuals. If they won't listen, pursue all alternatives. The potential rewards justify considerable effort and perhaps some risk-taking. Good luck!



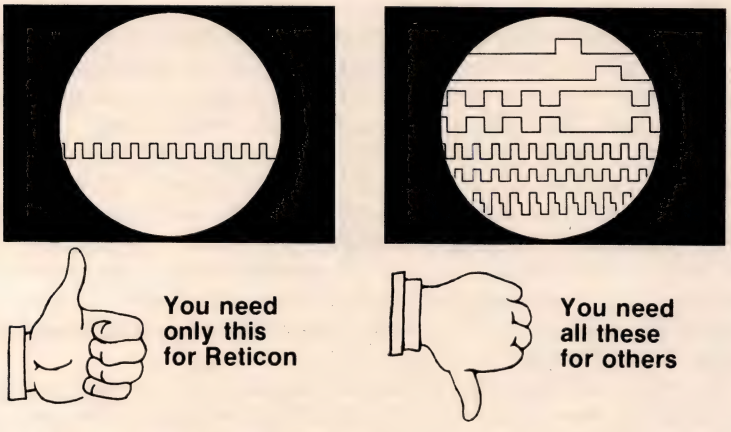
Walt Patstone
Editor

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23 Part I approvals in 13 months ...

Acceptance of High Rel COS/MOS is climbing fast.

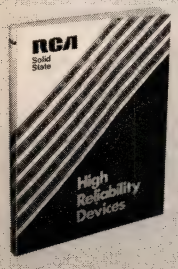
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CD4009A	05501	CD4021A	05704
CD4010A	05502	CD4022A	05604
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Write: RCA Solid State. Box 3200, Somerville, N.J. 08876; Sunbury-on-Thames, Middlesex TW16 7HW, England; Ste. Anne de Bellevue H9X 3L3, Canada; Fuji Building, Tokyo, Japan.



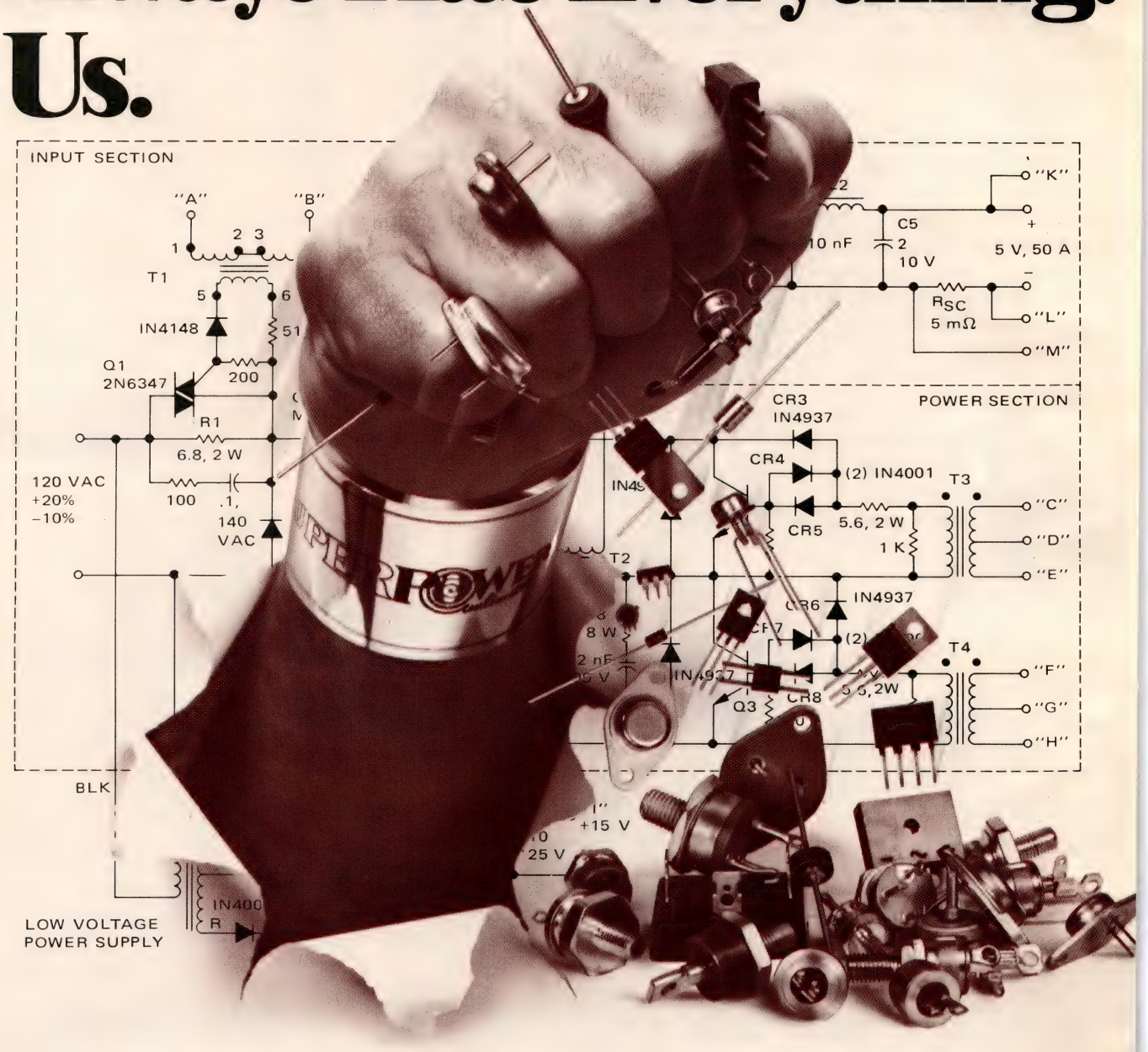
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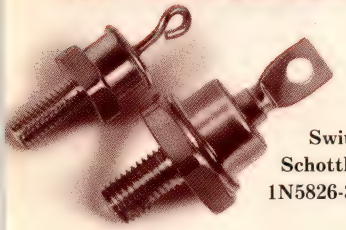
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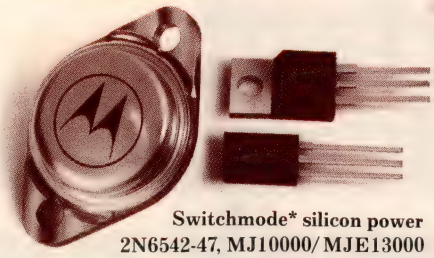
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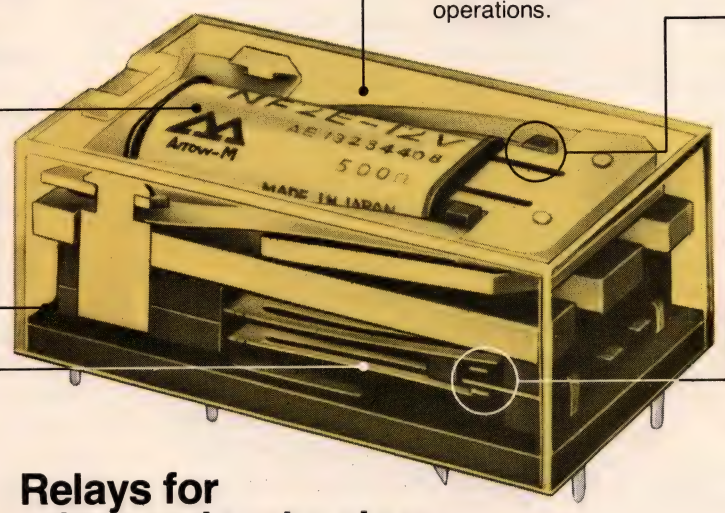
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Three-channel side-scan sonar detects Loch Ness "monsters" and ancient ruins

Paul Snigier, Associate Editor

Do prehistoric dinosaurs—plesiosaurs, to be specific—survive today in the cold depths of Scotland's Loch Ness?

Sonar tracings have disclosed amazing new discoveries (revealed here for the first time) that involve what appears to be the skeleton of such an animal, as well as a carcass shape with neck- and fin-like structures resting on the bottom.

As if this weren't mind-boggling enough, other findings show that mysterious stone structures literally dot the bottom of the lake!

To get the full story, EDN's Paul Snigier and John Conway journeyed to Klein Associates, Salem, NH, to meet the creator of the sonar system, Marty Klein, and sonar engineer Charles Finkelstein. They offered some background details first.

The environment of Loch Ness

The Loch is long and narrow, stretching southwest and northeast about 22 miles, with a fairly uniform breadth of about a mile and a maximum depth of 780 ft. Its temperature remains unchanged, year-round—a cool-but - not - cold 42°F —warm enough, according to Woods Hole experts, for a large reptile to survive. The steep-sloping underwater walls of the lake drop precipitously to great depths and have sharp ridges, undercuts and possibly even caves—places that could form excellent hiding spots for a large creature.

The Loch lacks vegetation, however, partly because its water contains peat suspended in solution that blocks out life-giving sunlight. Still, sea trout, pike, char and stickleback abound. Salmon fight their way up from the sea into the fresh water of the Loch through several rivers that drain from the lake.

An improved sonar system

Marty then went into the details of the trace.





Fig. 1—Marty Klein (a), aboard the 33-ft Malaran at Loch Ness, examines the HYDROSCAN Side-Scan Sonar/Sub-Bottom Profiler Towfish. The transmitter is at front; the receiving arrays, inside the fish and located further back. A special cable made of lightweight DuPont Kevlar, with steel-like strength, is attached to the fish at two locations. The Towfish transducers **(b)** project ultrasonic acoustical pulses that spread outward. Returning echoes are converted to electricity, amplified and processed to produce a picture of the sea floor that resembles an aerial photo. *(All photos are copyrighted by Klein Associates and the Academy of Applied Science.)*

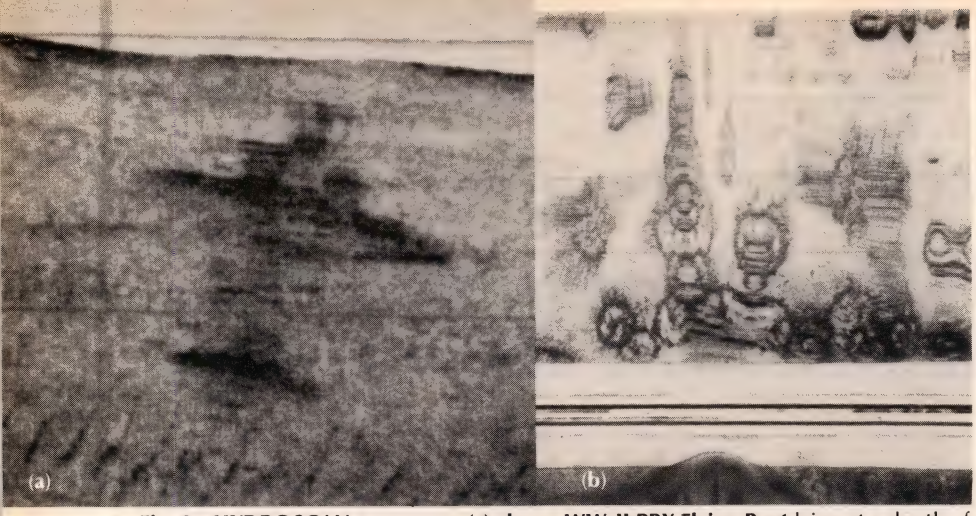


Fig. 2—HYDROSCAN sonar scan (a) shows WW-II PBY Flying Boat lying at a depth of 100 ft on the Loch's bottom. This sonar "picture" **(b)** of "Kleinhenge" shows many stone formations discovered by Klein. Note that one of the formations consists of multiple circles and is 250 ft long. Are these formations Celtic in origin? If so, they may prove one of the greatest archaeological discoveries of recent years!

"Though sonar researchers at the Loch have shown that, on many occasions, large objects move beneath the surface, our idea was to use the Klein 431 HYDROSCAN Side-Scan Sonar/Sub-Bottom Profiler System to detect carcasses or skeletons on the lake floor. Tests from our boat in a lake near Salem, NH, had already confirmed that our sonar easily picked up mammoth bones placed on the bottom.

"Let me describe the system. "The transducer arrays are enclosed inside a sleek aluminum or stainless-steel, rocket-like torpedo called the 'Towfish' **(Fig. 1a),** which is towed below the water behind the boat—generally only 15 ft down. The device emits an ultrasonic 100-kHz sound wave that quickly spreads out to the left and right **(Fig. 1b),** and strikes the bottom, reflecting echoes back.

"These echoes are then processed by the Model 431 3-channel recorder, which, unlike previous split-trace, single recorders, is not multiplexed and prints all three channels simultaneously—two side scans and one sub-bottom profile. The graphic record, created electrostatically on dry paper, often resembles aerial photographs!

"We experimented very successfully with a variety of signal-processing techniques, including Hands-Off-Tuning® with Texture Enhancement™ to bring out finer details and make interpretation of difficult areas easier. We also tried experiments with Variable Texture Enhancement ™.

"A third transducer in the Towfish has a lower frequency capable of penetrating the lake's bottom. For our work in the Loch, the side-scan frequency was 100 kHz, with a horizontal beam angle of 1°, and a pulse length of 0.1 msec. Our profiler transmitted on 3.5 kHz, projecting a 5°-conical beam with 0.4-msec pulse length."

Search for a fabled monster

"After arriving at the Loch on June 27," Klein continued, "we profiled the sediment layers with the 431 and, interestingly, found what a geologist interpreted as a buried ancient river bed! Soon the sonar also spotted a World War-II PBY Flying Boat resting on the bottom **(Fig. 2a).**

"Our search for bones began in the shallow parts—a difficult job, since hardly any shallow parts exist! Urquart Bay, Bores Bay, Lochend, Borlum Bay and near Cherry Island—we searched them all; and much to our amazement, every bottom area revealed odd patterns of stone: Some were circular and concentric; others, rectangular; and some, straight **(Fig. 2b).**

"We went on with our work, wondering what these patterns were. Finally, we dove on one at Lochend, and found a circle of stone 30 feet across, with a smaller 15-ft stone circle inside!

"Other circular and half-square stone structures, as well as lines resembling an ancient beachline, dot the submerged bottom to 80 ft.

"These stone structures, per-

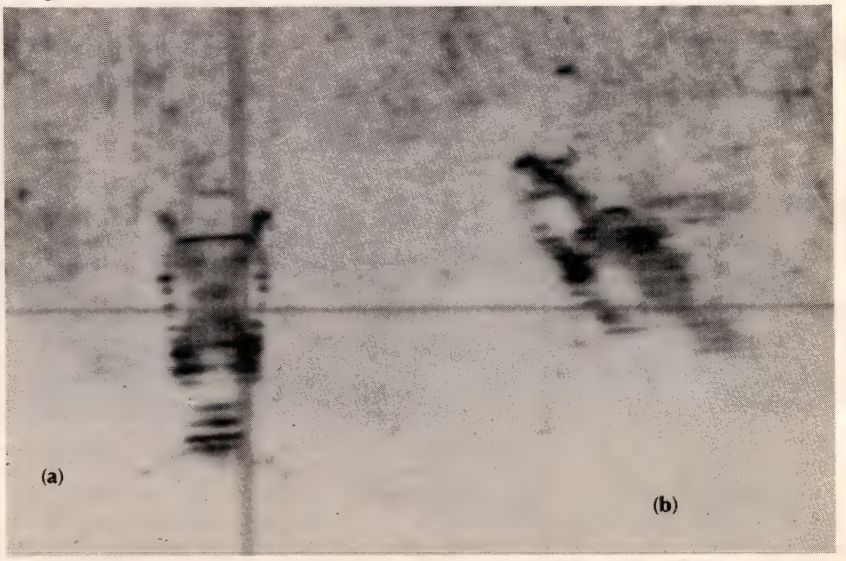


Fig. 3—This trace, one of many, shows a submerged barge (a) appearing as an X-shape, and an inexplicable form **(b)** next to it that had not appeared on the trace in previous investigations.

haps built by the Celts, indicate that the lake bottom may once have been dry land. If so, the Loch has preserved what may prove one of the greatest archaeological discoveries of this century!

"Next, we found more structures, yet completely different, in a deeper 80-ft bottom; and if you look at the sonar prints, you'll see a row of 250-ft dots emanating from these formations. Are these the remnants of some prehistoric stone-age tribe? Or maybe a new Stonehenge?

"We also looked at the Loch Ness walls and detected a distinct pattern that resembles a submerged cave opening 9-ft square.

"Later," Klein concluded, "we picked up an unusual shape with a long neck-like projection and what could possibly be flippers **(Fig. 3a).** It was 30 ft long and at a depth of 330 ft, too deep for a dive."

"A riddle wrapped in an enigma"

Charlie added a final revelation.

"We observed other objects that appeared similar to the bones detected in our New Hampshire tests. I dove down to the sand-silt bottom to investigate. Instead I discovered clay-like clumps standing up from the floor—a very unusual phenomenon, considering clay doesn't form such patterns every day!

"I also saw clay 'shells', like shingles, on the sides, broke off a piece and took it up."

Data from this research project is still being analyzed. Whatever the final results, the inescapable conclusion has emerged: These scientific findings are only the beginning of a solution to the Loch Ness "monster" mystery! □

Laser scanning "looks" inside active semiconductor devices and safely reveals their functioning

A long-sought, nondestructive way of telling what goes on inside semiconductors is now a reality. With the laser flying-spot scanner, you can map dc and high-frequency gains in transistors; detect device areas that are operating in a nonlinear manner; and electronically map device temperature and detect the location of "hot spots." You can even change individual logic states in a single shift-register cell.

Mapping is performed by scanning the semiconductor device with light from a low-power CW laser. This creates electron-hole pairs within the structure. These current carriers can then easily be detected, since they enhance the signal current-carriers supplied by leads fixed to the device.



A nondestructive look at the inner workings of a semiconductor device is possible for NBS scientists David W. Berning (L) and David E. Sawyer (R), shown here using the laser scanner they developed for the process.

The process is painless

Unlike investigations with an electron microscope, laser scanning does not damage the semiconductor, and thus allows for in-depth studies.

For example, take a static dual, 128-bit PMOS ion-implanted shift register. With the flying-spot laser scanner, you can observe operation of the register without altering device characteristics. All that's needed is to connect the package leads as appropriate for normal circuit operation, focus the scanner's raster on the register, and use a scope to display a synchronized map picture of device operating currents.

With this setup, logic flows are readily traced on the scope presentation. It's easy to observe ONE's and ZERO's, and marginal or defective cells show up plainly.

By selectively focusing the attenuated laser beam on an

individual cell, you can also change that single cell's state. Directing the laser beam to one side of the cell changes a ZERO to a ONE, while aiming it at the other side reverses the state. Adjacent cell status remains unchanged.

Of course, such an optical scanning technique proves useful only when it is possible to get light into a device. However, today's trend toward interdigitated structures and semitransparent polysilicon conductors for MOS circuits makes such an application simpler.

National Bureau of Standards scientists David E. Sawyer and David W. Berning developed the laser flying-spot scanner and demonstrated its capabilities. More details are provided in NBS Special Publication 400-27 that contains the script for a video-tape presentation on the subject. Send $1.20 to the U.S. Government Printing Office, Washington D.C. 20402, to obtain this document.—*ED*

Copper foot will put the "finger" on footwear heat-loss problems

Future U.S. servicemen may have more comfortable feet, thanks to a copper foot under development by University of Utah researchers. Built in the shape of a standard size-9 human foot, the electrically heated form will be used by the Army for checking efficiencies of various types of footwear.

Charles D. Baker, principal investigator on the project, succinctly summed up its objectives: "The Army uses dozens of types of footwear, from flight boots and arctic gear, to combat boots and tropical gear. Each can be used with many different types of socks and liners. What we are building is a foot calorimeter that will test how efficiently a boot or a sock prevents or enhances heat loss from the foot."

Toe bone connected to the...?

Researchers first made a plaster mold of a standard size-9 foot model. Then, a 1/8-in. thick copper shell was electroplated over the mold.

This copper shell was cut into three main sections—toe, center and heel—and then subdivided into 27 separate plates.

The plates, each equipped with its own heating coil and temperature indicator, were then reassembled on a plastic model of the original form. For easier insertion into boots, the plastic foot is also cut into three interlocking sections.

To begin the test, each section is turned on, and the temperature is stabilized at 98.6°F. Then the foot, already inserted in the sock or boot to be tested, is placed in the appropriate (hot or cold) test chamber.

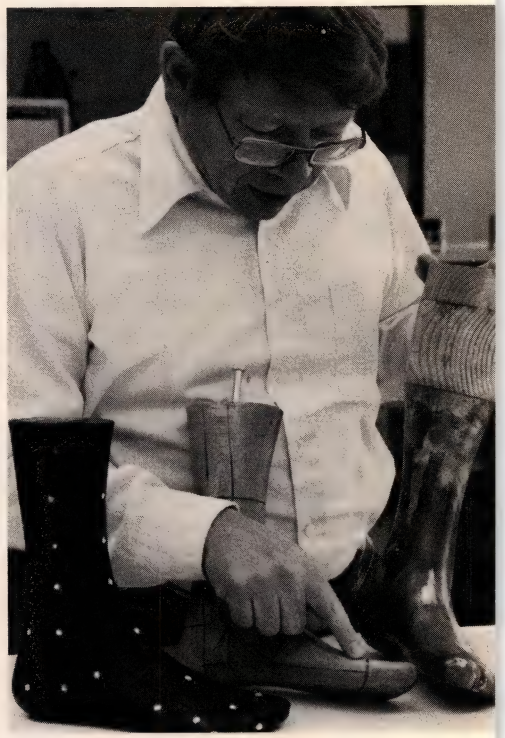
The 122 wires coming out of the model are fed to a computer that monitors the variation in current required to maintain a constant temperature in the foot. Increased current drain is synonomous with high heat loss and low footwear efficiency.

Giving it the "hot-foot" test

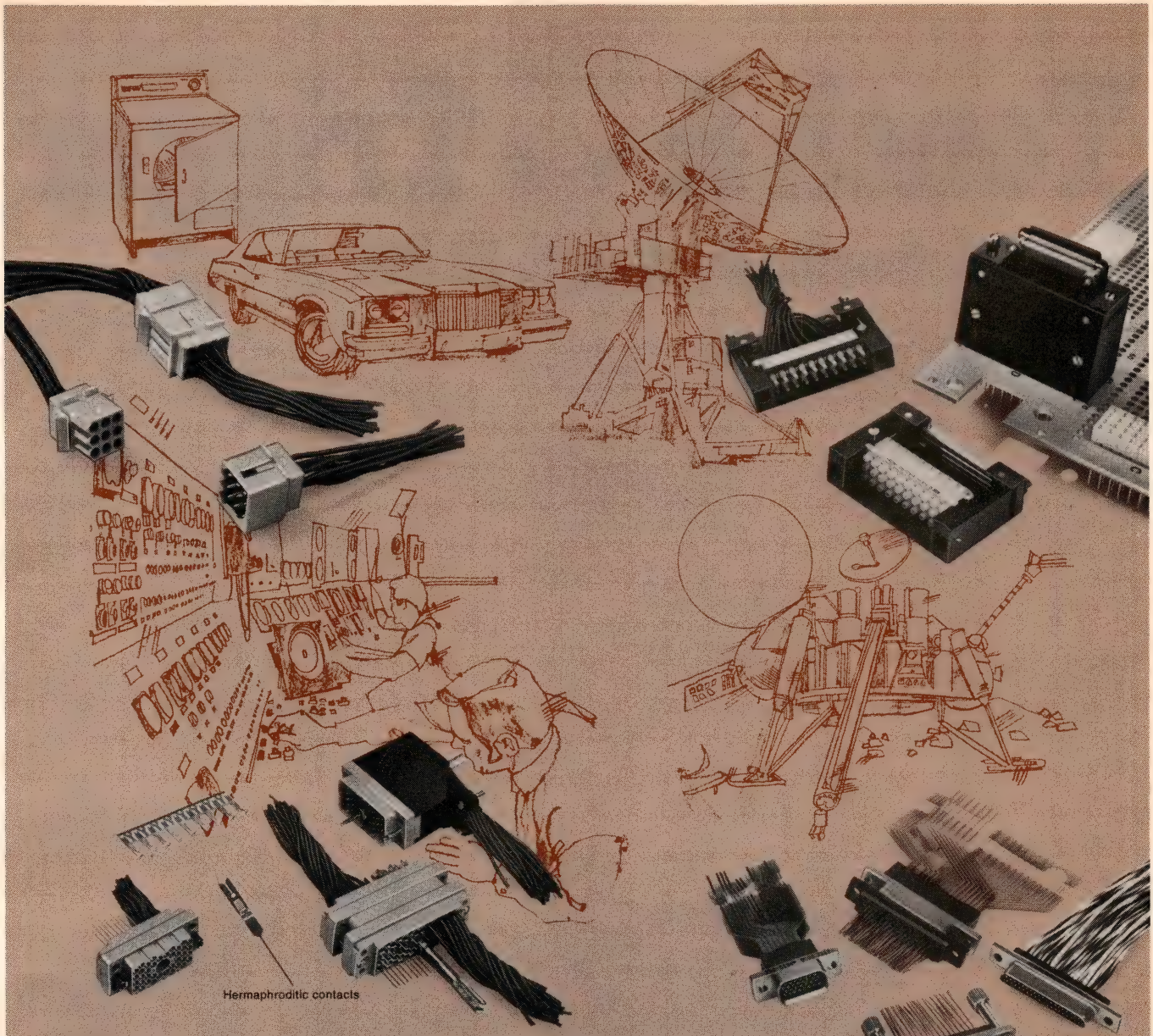
To minimize heat transfer, the 27 copper plates covering the foot are slightly separated. Such a design will allow Army testers to exactly pinpoint where the greatest heat loss occurs.

This new test system offers two very significant advantages when compared to the process it replaces. Since the older system utilized a continuous copper surface, pinpointing specific heat-loss areas proved impossible. Also, the older model was incompatible with computerization; this factor alone could be a "terminal condition" in today's electronic market.

Technology development is really the hardest part of the project. If successful, subsequent project phases should evidence smooth sailing. The Army has tentative plans to follow up this project with a copper hand for testing gloves, and then an entire copper body for determining clothing efficiency.—*TO*



Finding out where the heat goes will be the job of the copper foot (shown on the right) now under conversion into a calorimeter by the University of Utah's Biomedical Test Lab for the U.S. Army. At the left is a painted plaster model with dots showing where heating coils will be placed in the final copper foot.



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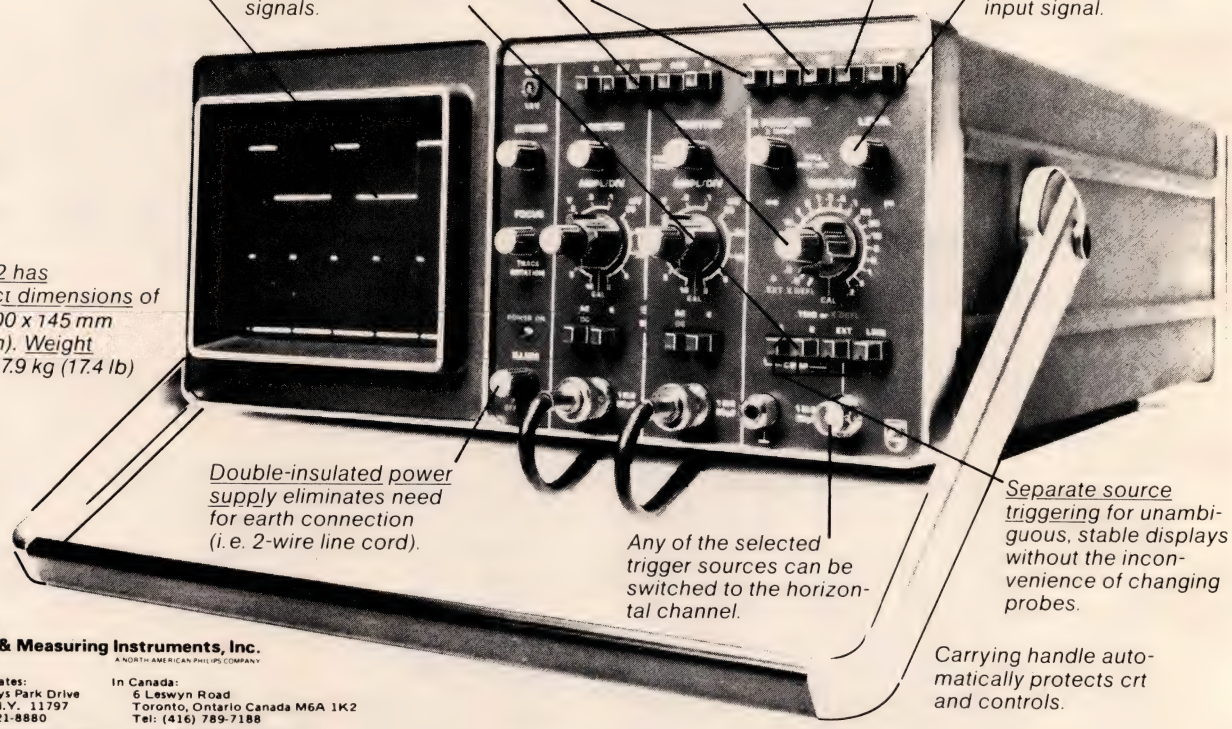
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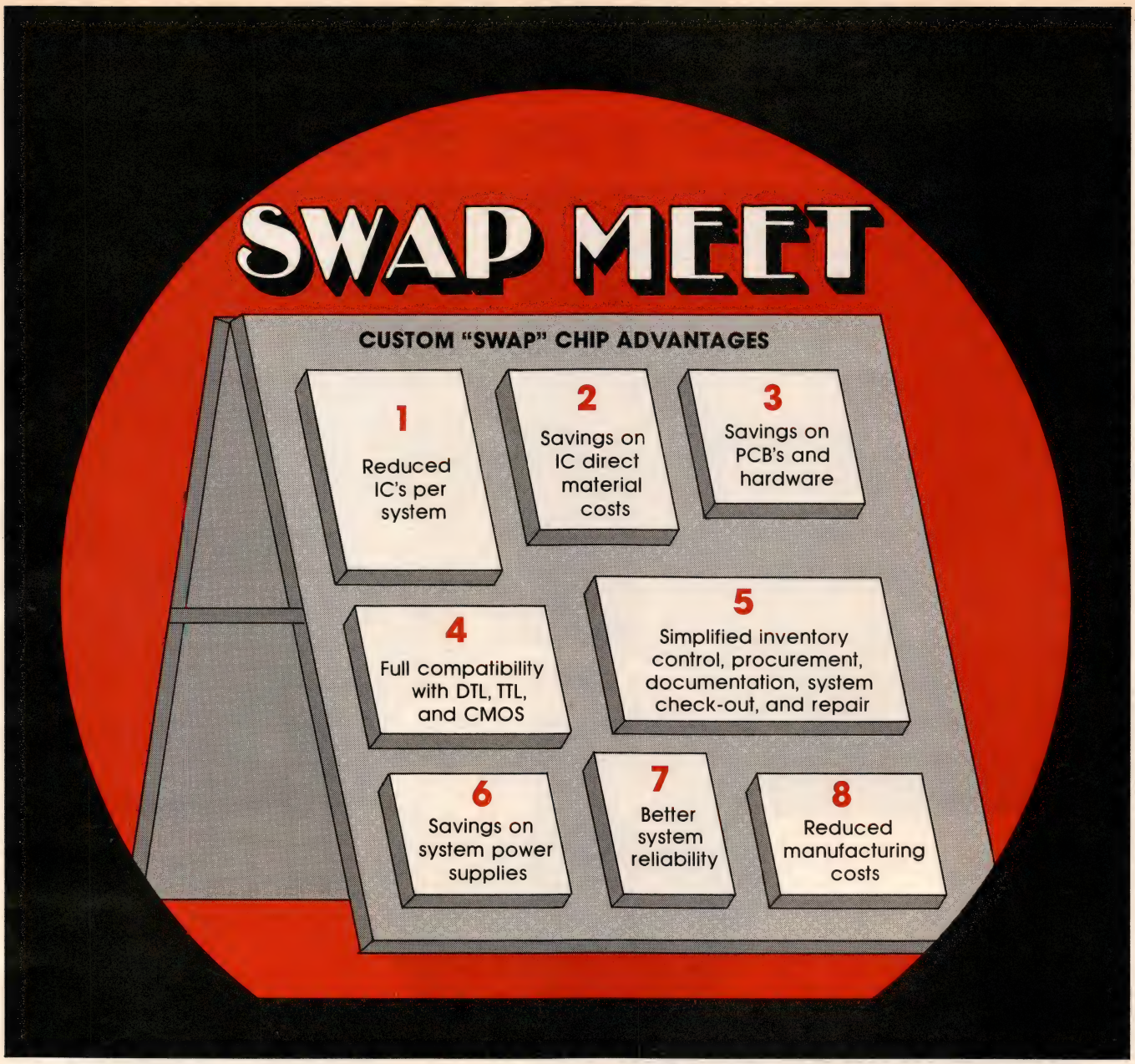
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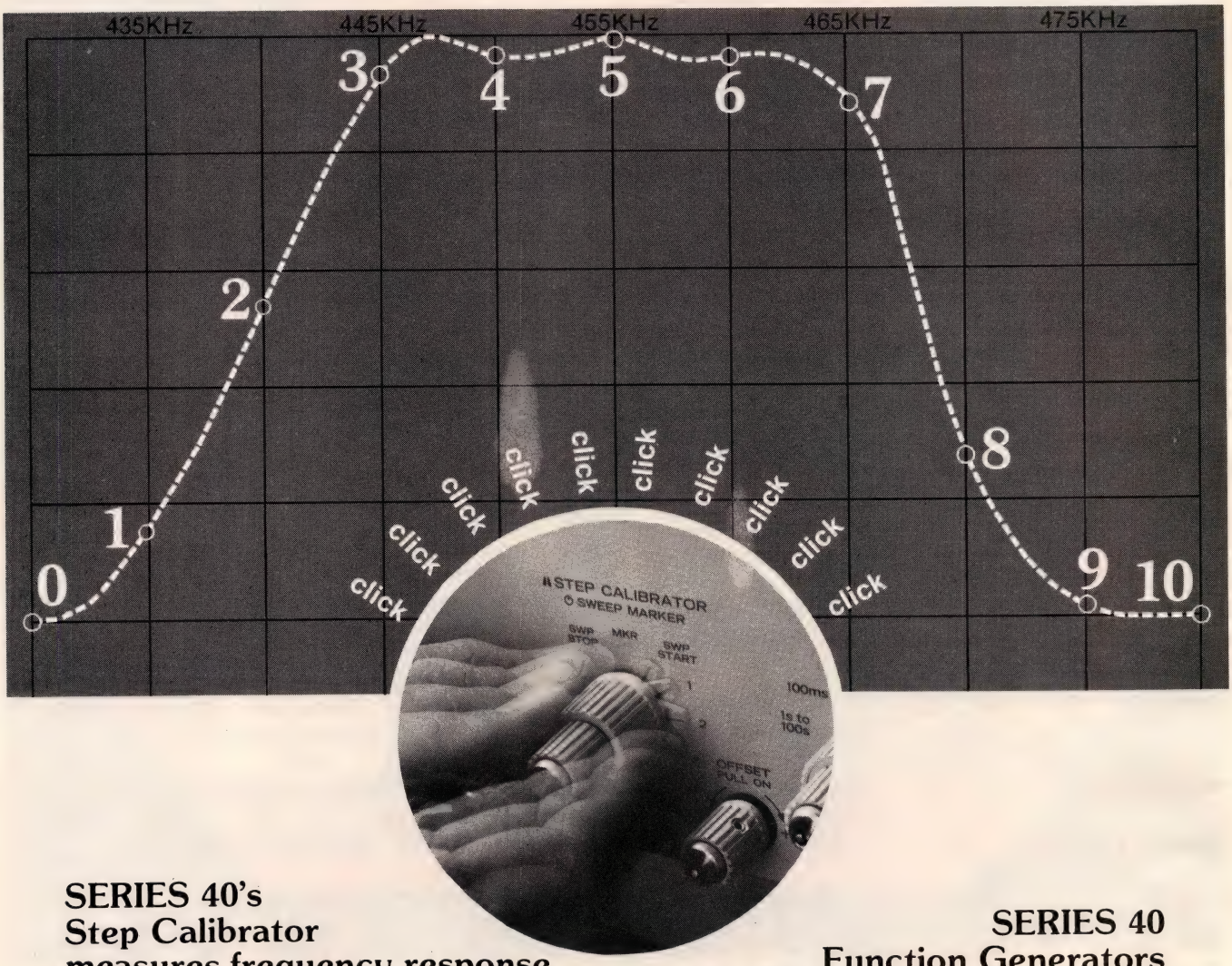
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μP digs signals out of a very noisy environment—outer space!

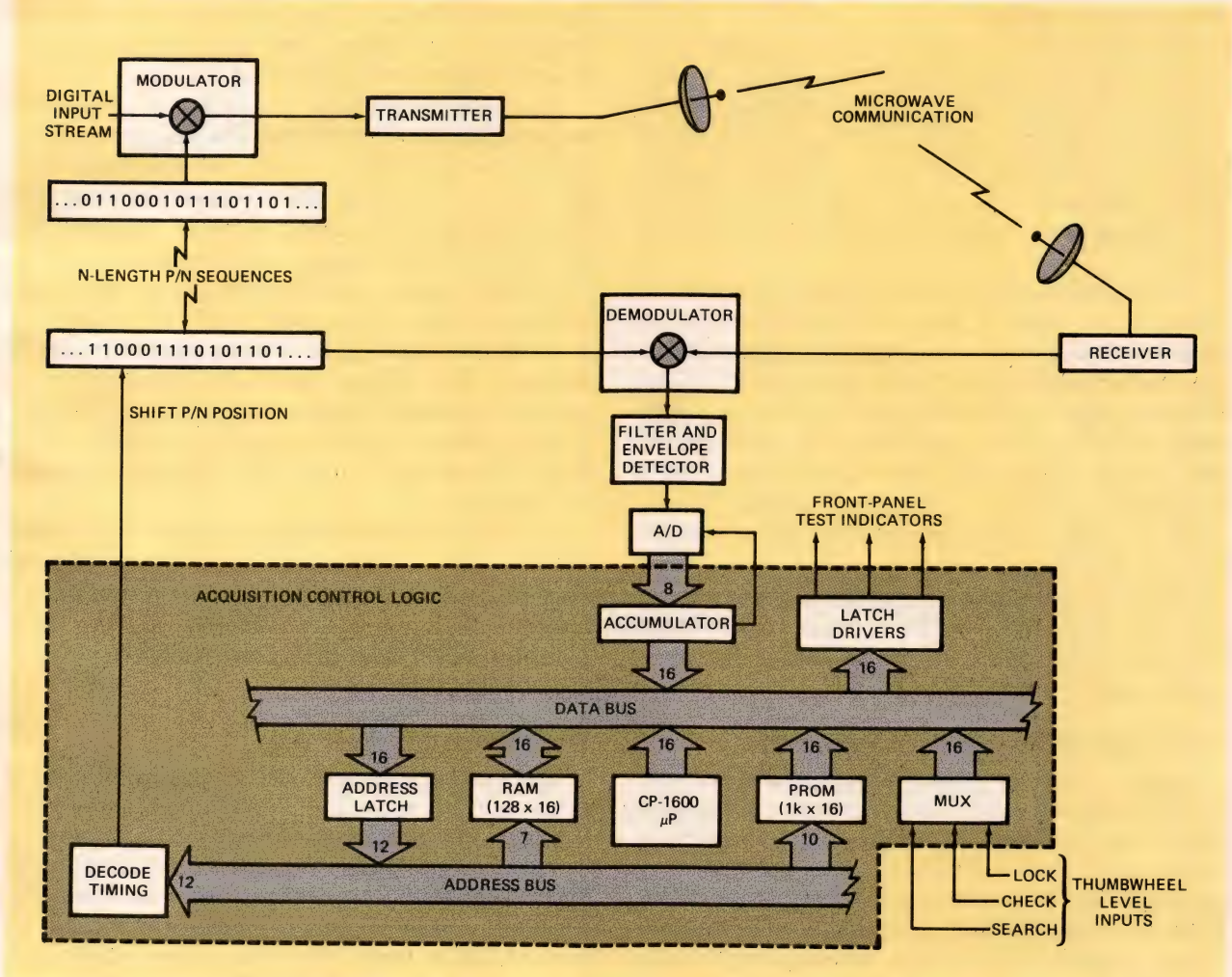
Try to imagine the complicated communications systems and data-transmission problems associated with the spacecraft "Enterprise." No, we're not referring to the starship of "Star Trek" fame, but rather the space shuttle NASA rolled out for the first time in mid-September.

NASA, currently performing laboratory studies on various shuttle-orbiter microwave-communication links, has contracted the Harris Electronic Systems Division of Melbourne, FL to implement a μP-controlled spread-spectrum modem as one approach to these problems.

Spreading the transmission over a wide range

Spread-spectrum techniques offer two distinct advantages for space communications: energy dispersal over a broad range of frequencies and significant information-processing gains in the presence of narrowband interference.

In this system, digital inputs combine with a fixed-length pseudorandom-number (P/N) sequence composed of a repeating binary pattern that may range, in this application, from only three to 128k bits long. (NASA selected a 2k test-bit length.)



By synchronizing a P/N sequence on the ground with a similar pattern generated in space, the CP-1600 can detect a spread-spectrum signal modulated over a broad range of frequencies; this method uses much less energy than signals modulated by other techniques.



Front panel of the demodulator lets the user set operating parameters without knowing he is interfacing with a computer-type controller.

For almost every modulation technique, faster modulation implies a wider output frequency range; in this case, the 11-MHz P/N sequence modulates the slower digital data stream fast enough to produce a spectral occupancy of about 25 MHz. In every instance, the transmitted spectrum expands to a range proportional to the P/N-sequence length.

Demodulation, a most demanding process in this system, takes advantage of the μP's outstanding computational and control capabilities. A P/N sequence identical to that mixed with the original data stream must be generated. Then, when an RF mixer subtracts this sequence from the filtered spread-spectrum input, the original data stream emerges.

Achieving synchronization between the relative position of these P/N sequences comprises a major system problem and the μP's biggest task. But because the energy level from the RF mixer rises as time correlation between the two P/N sequences increases, the processor can measure this energy and feed back instructions to a sequence shifter to maximize output levels. Lock-in time varies with P/N-sequence length, but the two strings generally sync within several seconds of signal input. Since the μP cannot sync the two closer than one bit, a phase-locked-loop fine-tunes the demodulator sequence for optimum performance.

Cut energy 98% while decreasing errors

Senior engineer Stan Padgett explained the significance of a spread spectrum: "Originally NASA had studied a number of transmission techniques, but calculations showed that they required more narrow-band energy than CCIR (The International Radio Consulation Committee) criteria allow. In this case, when going from a standard transmission technique to spread spectrum total energy density (signal strength per cycle bandwidth) drops 98%. And because the energy modulates over such a wide range, the level at any given frequency stays well within established limits.

"In addition, interference signals in one narrow band obscure only a small fraction of total transmission energy, allowing signal recovery with low error rates in noisy environments. In fact, the μP-controlled system handles a S/N ratio (power ratio) of −10 dB at a 700-kHz IF bandwidth—10 times more noise than signal!

"After NASA decided spread-spectrum systems were worth investigating, they contracted us at Harris to develop a manually controlled system which proved the concept but did not offer impressive acquisition performance specs. NASA returned to us for an updated version, and at that point we decided to go to microprocessor control."

How to choose a processor intelligently

After considering other alternatives such as a simple ROM-controlled sequencer, Harris chose a μP for several reasons: the large number of operator-interface formats allowed, ease of changing algorithms, and the ability to add system diagnostics in software.

Choosing a particular processor involved formulating a basic-system flow diagram from which the system parameters (which ruled the choice of μP) were developed: 16- to 20-bit accuracy for signal-averaging routines, flexible memory access, limited I/O demands, and most vital, speed. (The most critical timing path occurs when the processor must accumulate 16 8-bit A/D samples at a 16-kHz rate while simultaneously running multiply and divide routines.) Meeting such speed constraints, higher cost bipolar μP's used only a fraction of their capabilities, while slightly less efficient MOS processors emerged as most cost-effective.

With these selection factors in mind, General Instruments' CP-1600 seemed a logical choice. This 16-bit MOS machine provides a number of internal features easily adapted to the fairly complex arithmetic and data functions in the system algorithms.

Troubleshooting made easy

This system automatically tests several critical components, including RAM, upon power-up. While NASA officials watched, Harris engineers on-site first applied power to the unit, causing the RAM diagnostic lamp to light. After verifying the problem, these engineers picked up a replacement RAM at their local distributors, plugged it in, and the system performed perfectly. Thus, the internal diagnostic system proved itself, as did the concept of easy-to-repair microelectronics. □

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SSD5-30	5	4.7	6.5	30.0	27.0	22.5	15.0	295
SSD9-20	9	6.5	9.5	20.0	18.0	15.0	10.0	295
SSD12-15	12	9.5	13.0	15.0	13.5	11.2	7.5	295
SSD15-12	15	13.0	17.0	12.0	10.8	9.0	6.0	295
SSD18-10.5	18	16.0	21.0	10.5	9.4	7.8	5.2	295
SSD24-8.5	24	20.0	26.0	8.5	7.6	6.3	4.2	295
SSD28-7	28	25.0	33.0	7.0	6.3	5.2	3.5	295
SSD36-5	36	32.0	43.0	5.0	4.5	3.7	2.5	295
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8080 points to faulty memory chips in mainframe add-on memory system

Most engineers think of memories as subsidiary, even if vital, parts of any microprocessor system. But a new Intel add-on memory system turns the tables: A μP-controlled maintenance panel helps keep a much larger memory operating properly.

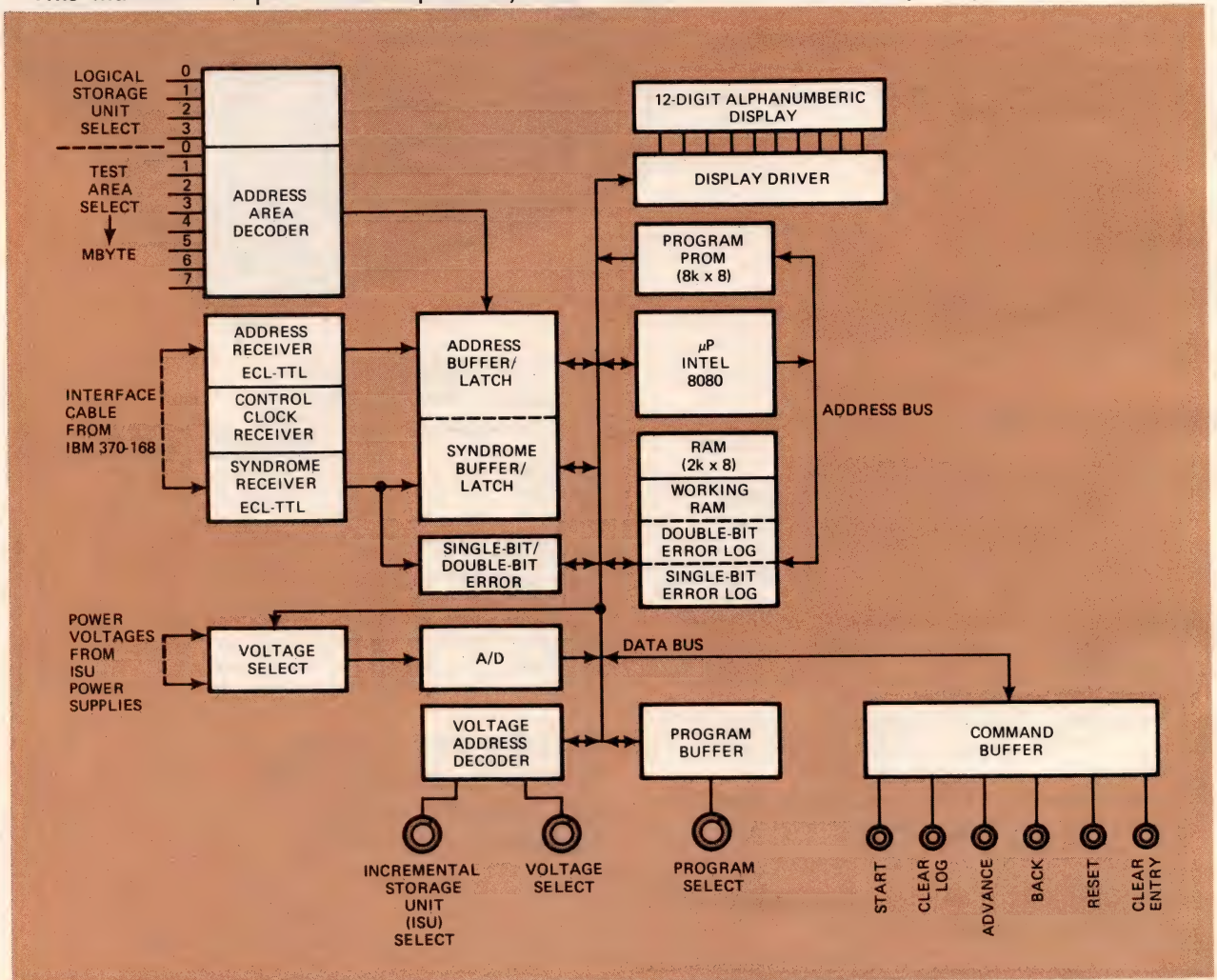
The Intel Memory Systems Model IN-7168 provides large memory capacity (up to eight megabytes in one-megabyte increments) for use with the IBM 370/168. Like other add-on's not supplied by IBM, savings attract many buyers, but reliability and maintainability make the sale: The customer shudders at the thought of downtime in his expensive computer, while IBM takes a jaundiced view when "foreign" attachments cause problems with their machine.

Learning from the memory's mistakes

This maintenance panel serves primarily as a flexible diagnostic tool that senses, logs and reports single- or double-bit errors, as well as monitors power-supply variations.

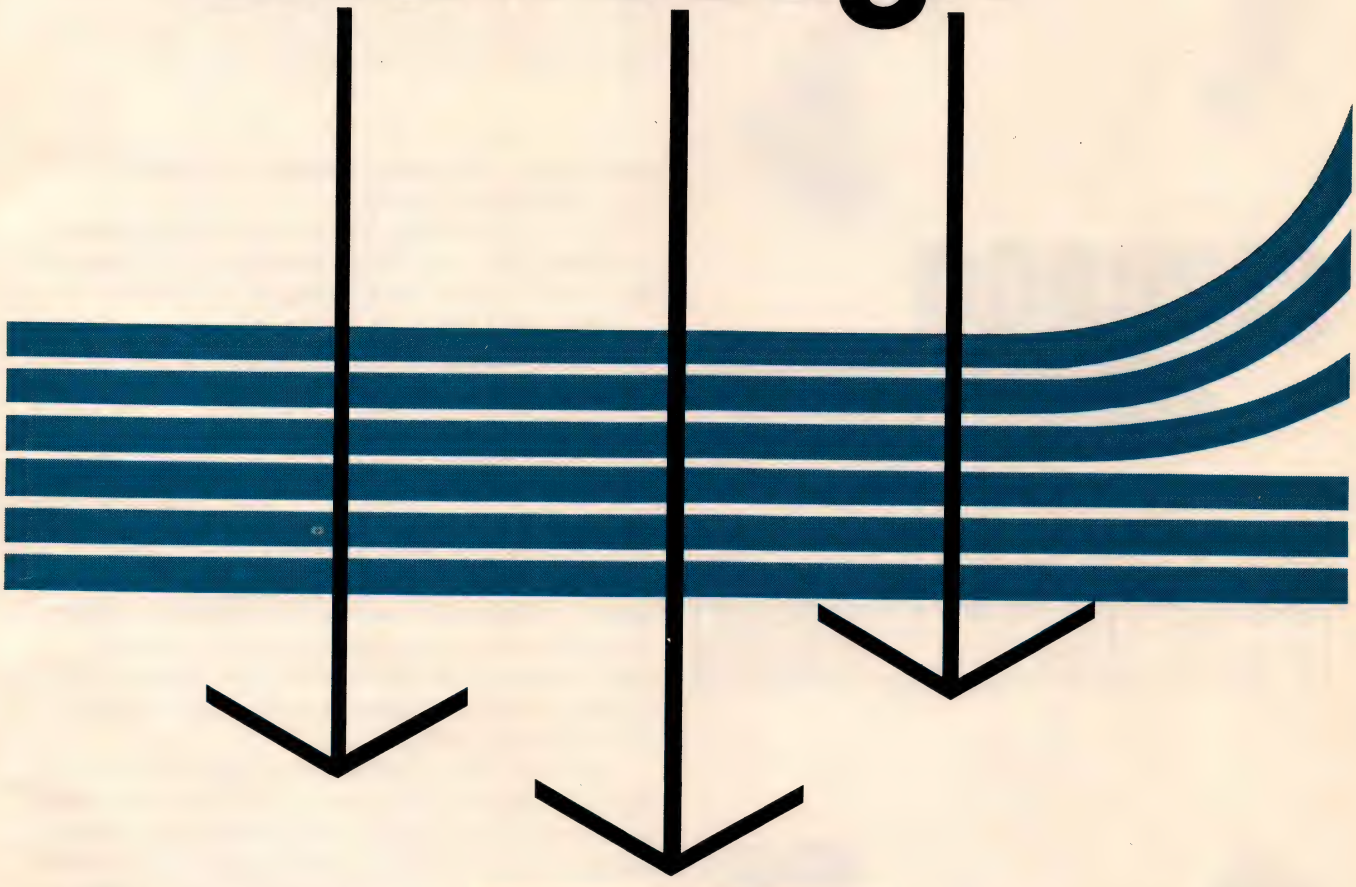
Although semiconductor memories, unlike core memories, exhibit a relatively large number of errors, the 370/168 automatically corrects for single-bit errors. It cannot, however, do likewise for multibit errors that, along with power-supply failures, account for most system failures. Such is the importance of error logging: The panel reports all errors detected, and a service engineer uses this information to lead him to boards or chips responsible for single-bit errors that he could replace while the system continues to work properly.

The panel keeps track of up to 400 error words generated by system memory chips, and logs them in order of frequency; error words for



Using only a fraction of the space in the add-on memory, this maintenance panel monitors voltage levels as well as detects and logs potentially system-disabling errors.

Anadex FP-600 prints perfect copies, through and through



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A total of 30 lines of numeric data can be printed in 19 columns at up to 2.4 lines per second, using either pressure-sensitive paper or standard paper with interleaved carbons.



the FP-600

Two basic models are available: the open-throat version that accepts forms of unspecified width; and the closed-throat version that accepts standard 3¼ inch cards.

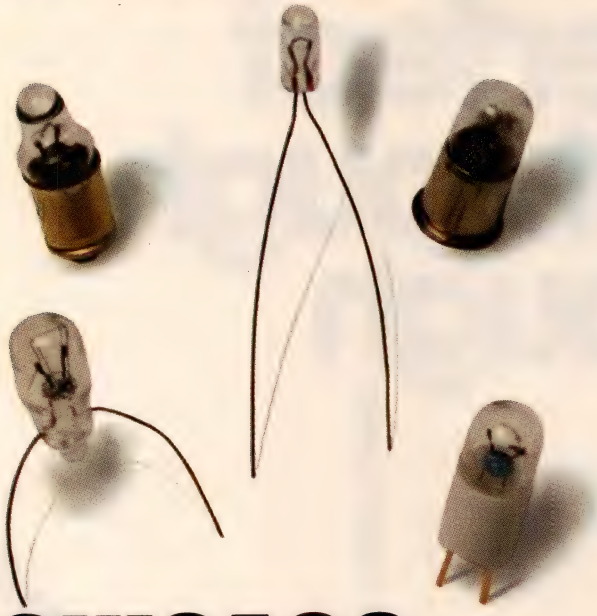
Options include a digital clock to record date and time, and a 3-digit counter to print sample numbers. Also available are bar code readers, card positioning systems and special print drums.

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For complete details and a demonstration, contact Ken Mathews, Vice President of Marketing at Anadex, 7833 Haskell Avenue, Van Nuys, California 91406, 213 / 782-9527; TWX 910-495-1762.

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Fully hardware and software compatible with the IBM 370/168 computer system, the Intel-7168 add-on memory contains a maintenance panel that logs and reports errors, allowing easy detection and replacement of faulty memory elements.

frequently failing chips therefore migrate to the top of the RAM error log.

Since uncorrectable errors may disrupt system operation, the contributing memory component must be located and replaced as quickly as possible. And although the panel cannot provide information on the data bits in question, correlating double-bit error addresses with addresses in the single-bit error log locates the responsible chip. (The system provides only 16 locations for multibit errors because they occur infrequently.)

How best to maintain a maintenance panel?

An Intel 8080 controls the panel in a straightforward configuration with other members of the MCS-80 family. Len Plewa, project engineer for this panel, found the Intel MDS system and the ICE-80 in-circuit emulation system most valuable in its development.

One interesting problem for Plewa was how to maintain the maintenance panel itself. Not being a usual memory-system component, service technicians would find it unfamiliar and automatically suspect whenever any problem arose. So Plewa designed in self-test plus self-diagnosis: A sequence of switch settings and button depressions check out the panel, and if malfunctions occur, the serviceman simply replaces a memory card in the panel with one containing special test PROM's that complete the test. This entire operation may take place off-line while the memory continues to run.

While this μP has obviously added attractive features to the standard add-on memory, Intel looks forward to applications in other new systems. □

Article evaluation: Please circle one on R.S. card.
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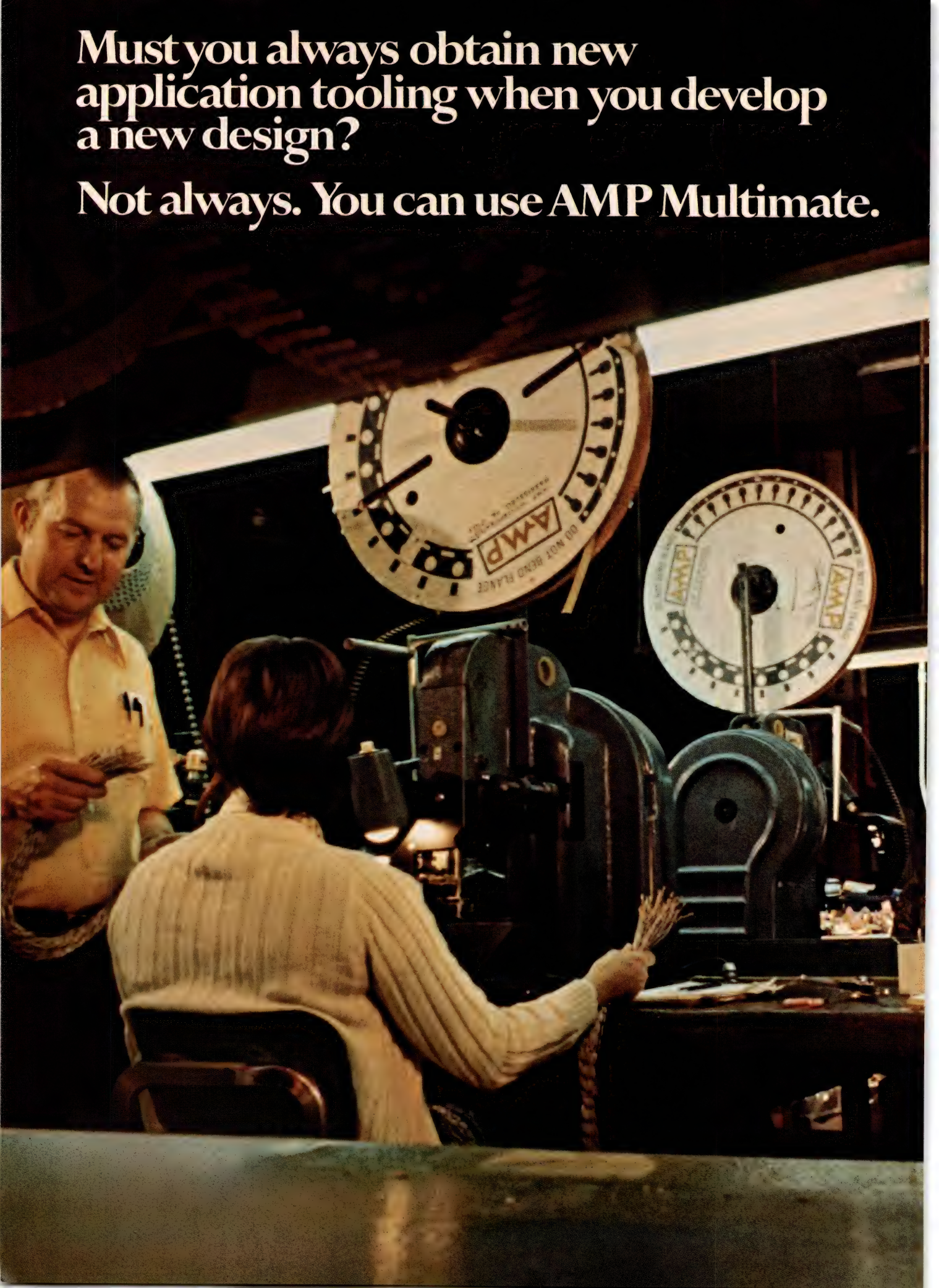
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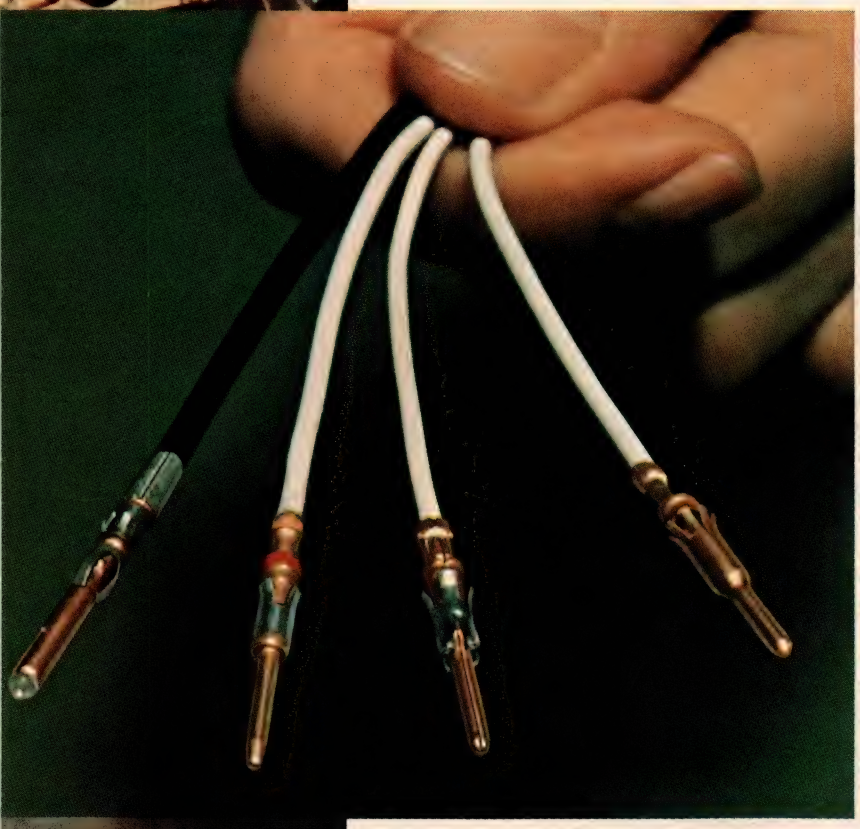
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Tracking generators stretch your spectrum analyzer's capabilities

Whether built-in, plug-in or stand-alone, the tracking generator makes spectrum analysis easier while increasing accuracy.

Peter Linden, Hewlett-Packard Co.

The spectrum analyzer (SA) is a versatile instrument for displaying the amplitude and frequency components of a signal, but it does have limitations. For instance: If you want a frequency readout to better than 1% accuracy, the SA's CRT won't help you. And if you want to measure a crystal-filter response over a 100-dB range, the SA's mixer will only guarantee distortion components 70 dB down (or worse, depending on the mixer's drive voltage).

The way around these limitations is to use a tracking generator (TG). Because the TG ties in to the internal-processing circuitry of the SA, it bypasses the primary source of distortion—the SA mixer—in the tracking process. Since a TG can in essence amplify a weak signal located by the SA's marker, it is also possible to obtain counter accuracy on otherwise impossible frequency measurements.

Reverse the conversion process

A tracking generator generates its signal by starting with its own crystal-oscillator signal and successively mixing it with the local oscillators (LO's) of the spectrum analyzer **(Fig. 1).** Signal flow in a TG is the reverse of that for an SA, mixing with the SA's third, second and first LO in succession before amplifying the output. This results in an output signal of precisely the same frequency the SA is tuned to receive. But since the generator and the analyzer share the same LO's, each TG must be designed for a specific SA.

Depending on the application, the TG can act as either a sweeper or as a continuous-wave (CW)

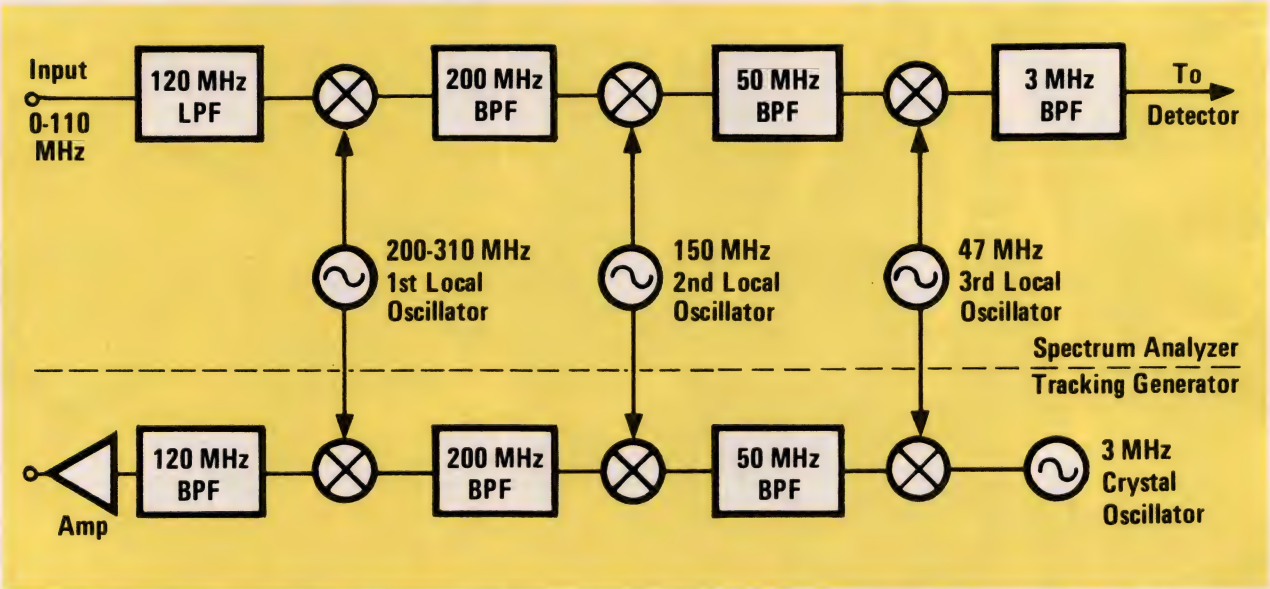


Fig. 1—A tracking generator's signal flow is the reverse of a spectrum analyzer's. Here, a 110-MHz tracking signal is generated by successive mixing with the SA's third, second and first local oscillators, respectively. A 3-MHz crystal oscillator originates the tracking signal.

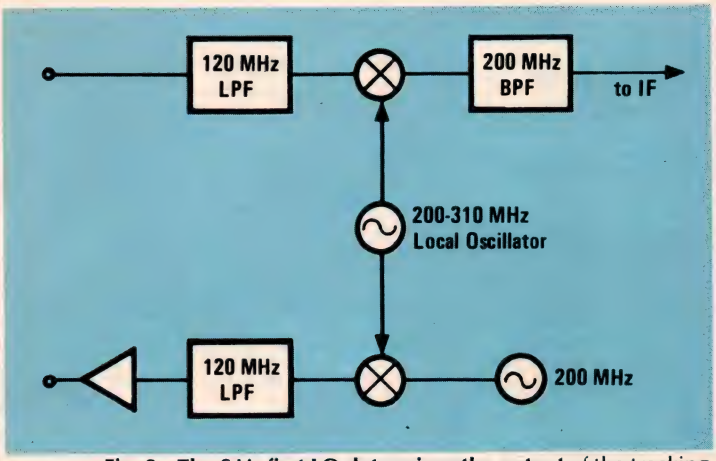


Fig. 2—The SA's first LO determines the output of the tracking generator. If this LO is sweep-tuned, the TG output will sweep. But, if it is fix-tuned, the TG outputs a CW signal. Assume the analyzer's first local oscillator sweeps from 225 to 275 MHz, which tunes the analyzer from 25 to 75 MHz. The tracking generator then outputs a signal that sweeps from (225 to 275 MHz) – (200 MHz), or 25 to 75 MHz, again. If the first LO is fix-tuned to 250 MHz, the analyzer receives a 50-MHz signal and the tracking generator outputs a CW signal at 50 MHz.

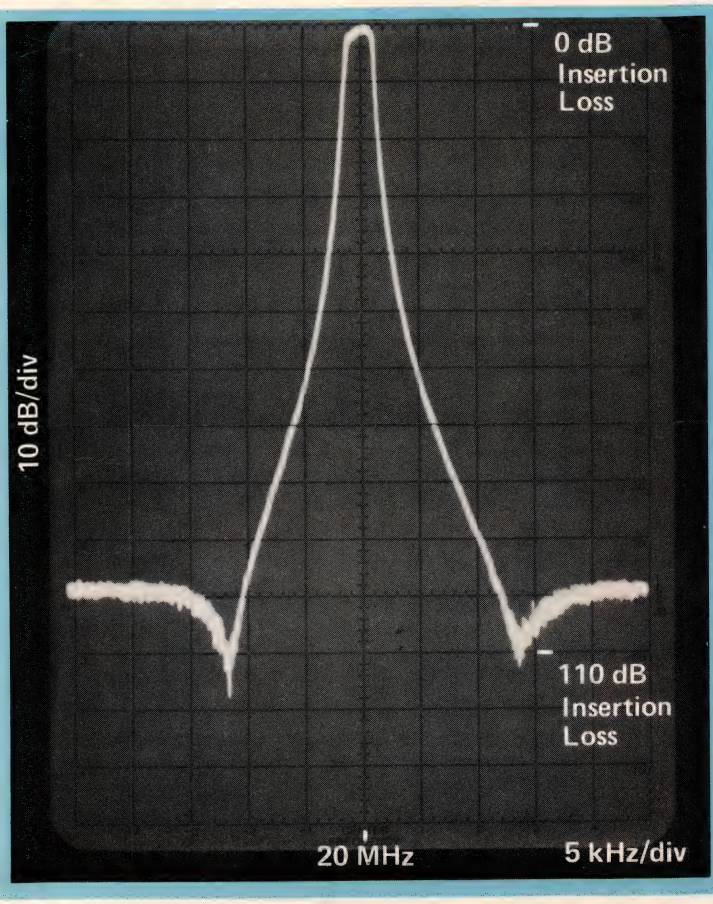
signal source **(Fig. 2).** If the SA's first LO sweeps, the SA and TG tune over the same frequency range and the TG outputs this range. Generally, the tracking-generator output level is highly calibrated and flat vs. frequency, making the output a good test signal for sweeping.

If the first LO is fixed-tuned, however, the spectrum analyzer becomes a receiver and the tracking generator, a CW signal source. As such, the TG can provide an output of sufficient amplitude to drive a counter, even though the signal to which the SA is tuned may be too small to register on a counter directly.

Bypass mixer distortion

When the tracking generator is used as a swept source it becomes, in conjunction with the analyzer, a highly tuned stimulus-response test system of up to 110-dB dynamic range. By inserting the device-under-test (DUT) into the TG/SA loop, characterization of devices such as filters, amplifiers or antennae is possible. Moreover, the SA/TG/DUT system avoids the distortion of the SA mixer at more than 70 dB down that would otherwise be encountered in an external-sweep/SA/DUT system.

This distortion is in the spectrum analyzer's mixer and its harmonics. If the fundamental is at 20 MHz in an externally swept measurement, for example, the mixer creates an undesired signal at 40 MHz on the CRT that obscures true signals at that frequency. With the TG/SA combination, however, the fundamental moves with the TG, which follows the SA. This means that by the time the analyzer tunes to 40 MHz by way of following the TG's signal, the SA mixer's second harmonic is then at 80 MHz, and so on. The tracked SA



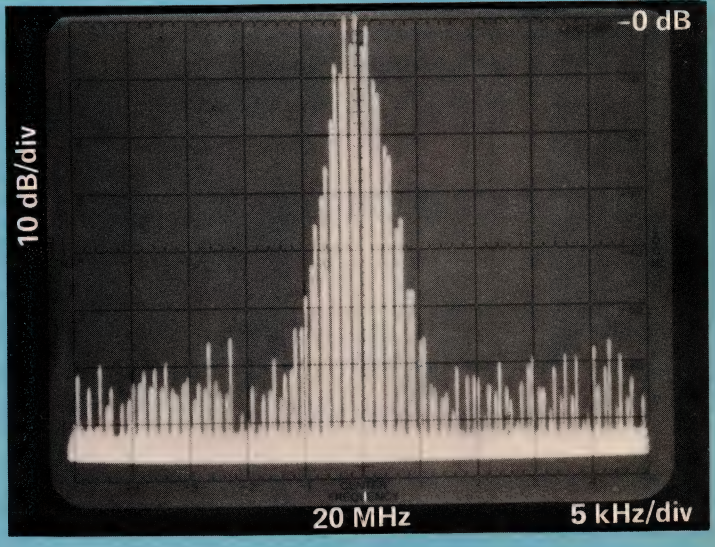
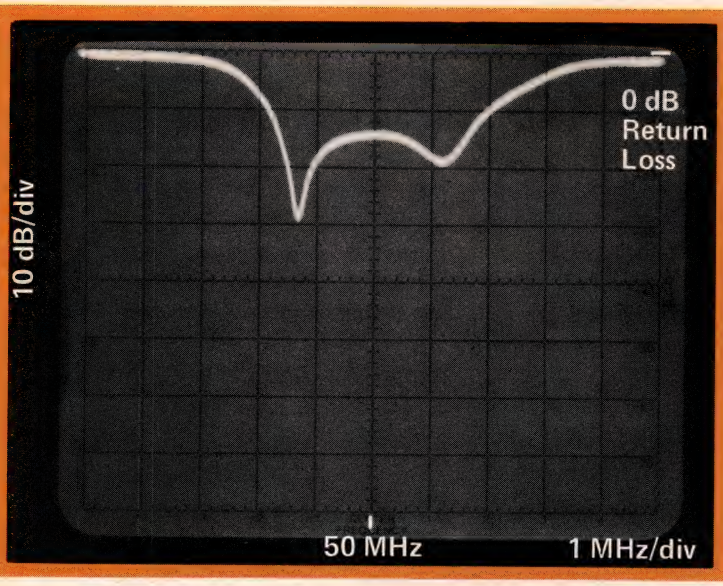


Fig. 3—Measure crystal-filter insertion loss by using a TG/SA combination that avoids the analyzer's mixer's internal distortion **(a).** With an external sweeper performing the same measurement **(b),** SA mixer distortion is unavoidable.



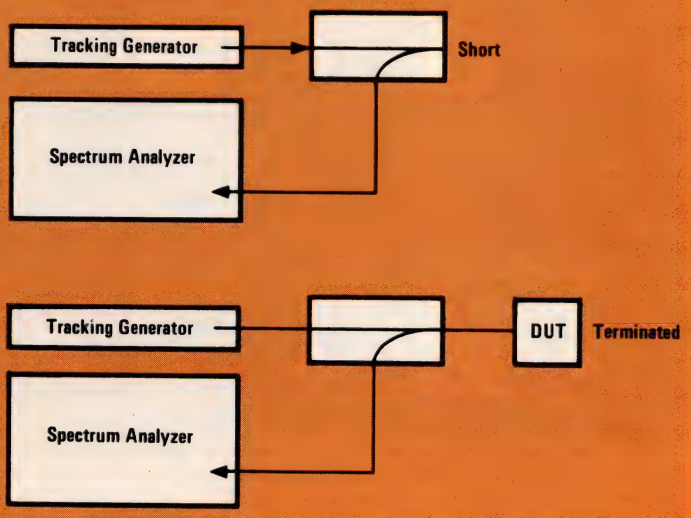


Fig. 4—To measure return loss, just use a directional bridge/coupler with your SA/TG combination.

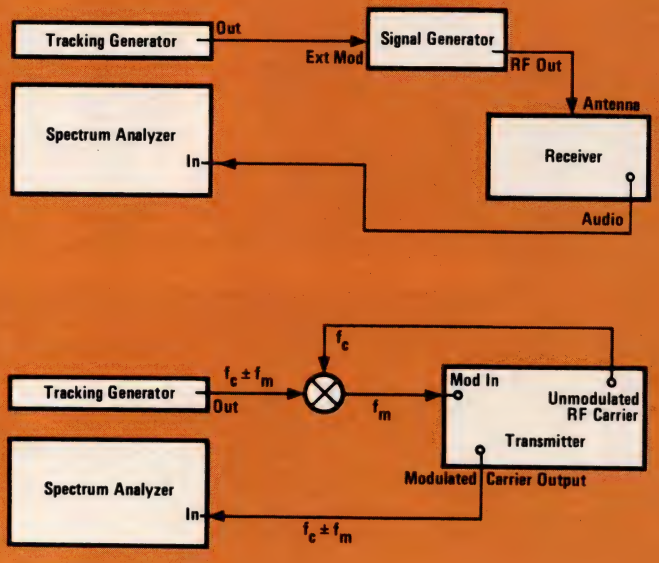
never has a chance to tune to its own mixer's distortion product.

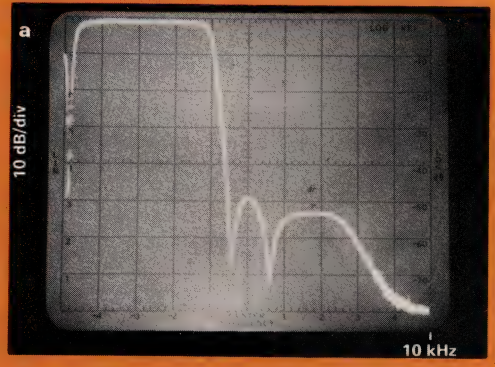
You can thus drive the SA's input mixer with signal levels up to, or even exceeding, its 1-dB gain compression point (typically −10 dBm) and still measure signal levels down to the internal noise level of the analyzer. For example, suppose you make a filter response measurement using a 1-kHz resolution bandwidth. If noise level in that bandwidth is −120 dBm, your measurement range can extend 110 dB, from −10 to −120 dBm.

Characterize linear devices...

On the work bench, of course, the most common measurements are the insertion loss and return loss of linear devices. With an SA/TG setup **(Fig. 3),** these become very simple operations. For an insertion loss, first calibrate the SA/TG system for 0 dB by means of a direct connection between the instruments. Then insert the DUT and read insertion loss relative to the calibration point directly on the CRT.

For a return-loss measurement **(Fig. 4),** calibrate the system by connecting the analyzer to the reflection port of a directional bridge/coupler, the tracking signal to the source port, and by shorting the load port. Then replace the short by the terminated DUT and observe the





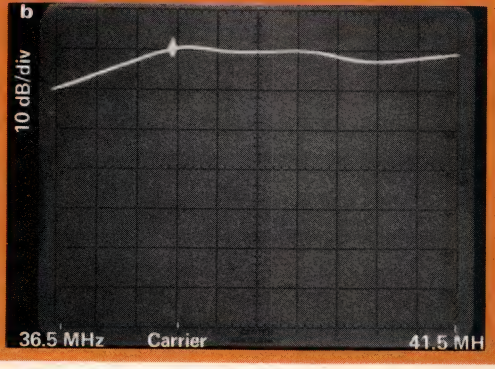


Fig. 5—TG/SA measurements can also include nonlinear devices. Here the tracking generator, used as a modulation source, tests both receiver **(a)** and modulator **(b)** responses.

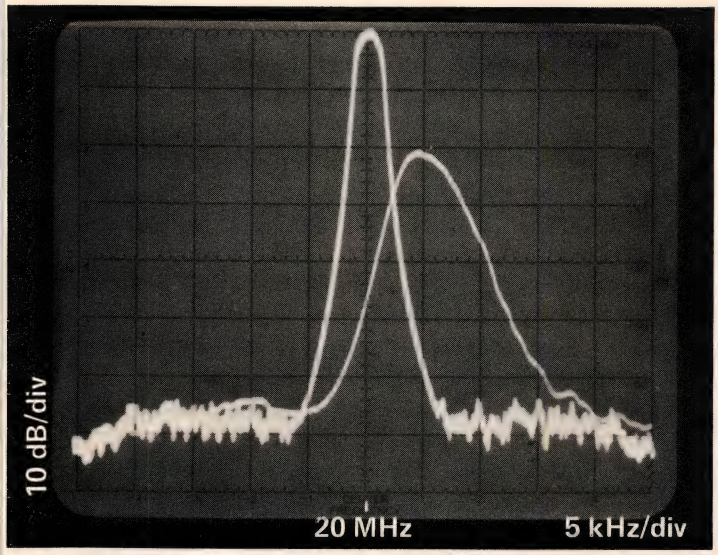


Fig. 6—Don't sweep too fast! Here's what can happen if you don't allow time for the DUT to respond.

return loss relative to the calibration point on the CRT.

...and nonlinear devices, too

Sweep-measurement applications aren't limited to linear devices; the response of frequency-conversion devices may also be measured. If you want to measure a receiver's response **(Fig. 5),** use the tracking generator as a modulation source: The TG externally modulates a signal

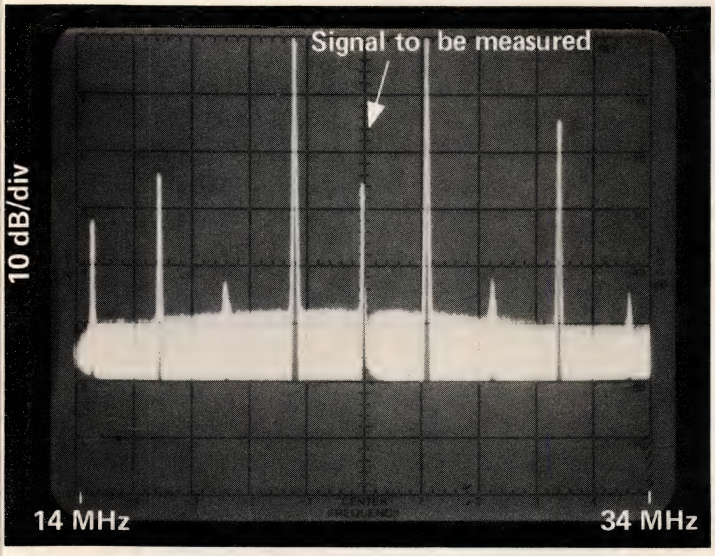




Fig. 7—Even low-level signals embedded among stronger signals can be measured using a tracking generator. Simply position the marker and connect a counter to the TG output.

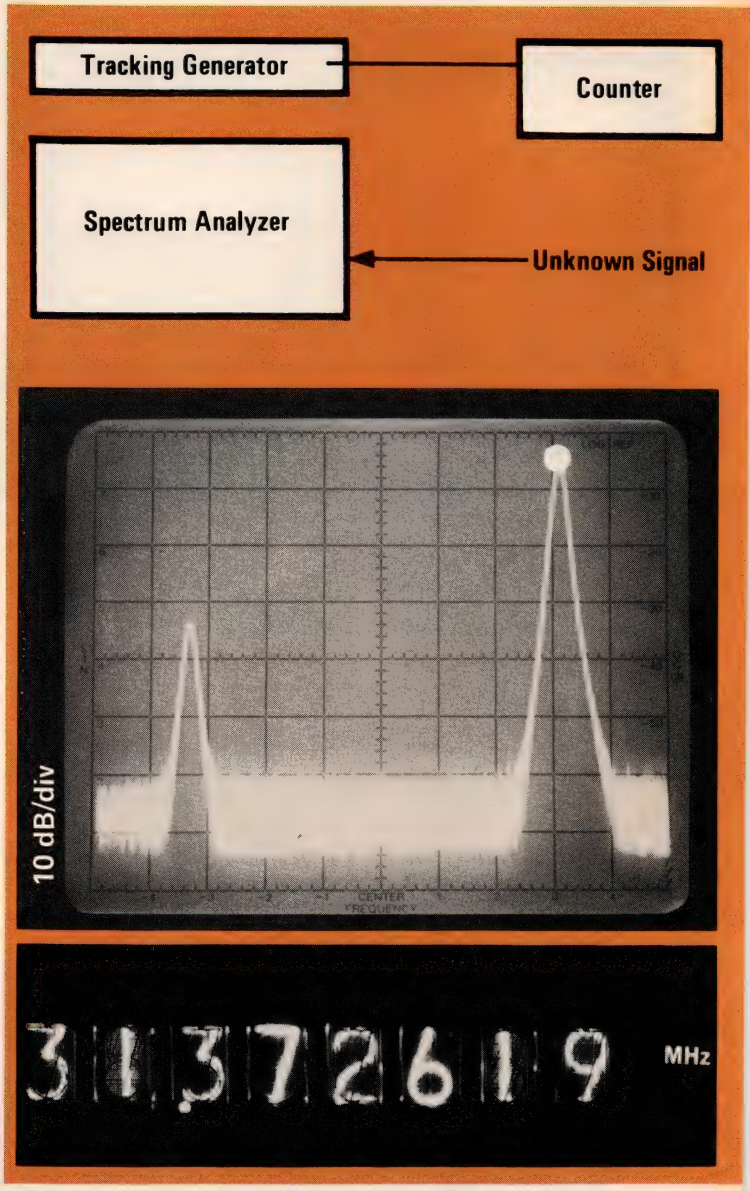


Fig. 8—To measure frequency with a tracking generator, just manually scan until the marker is at the peak of the signal to be measured and read the TG frequency on a counter.

generator while the receiver under test demodulates the signal and the spectrum analyzer views it.

In a related technique, modulator or transmitter response is analyzed by down-converting the tracking signal to generate a modulation source and then viewing the modulated carrier on the SA.

Account for DUT response time

Suppose you want to make a trickier measurement like viewing the reflection of an acoustic wave. Then you must take into account propagation time of the wave. With a tracking generator this is simple: Just offset the TG source frequency ahead of the analyzer's tuning by an amount

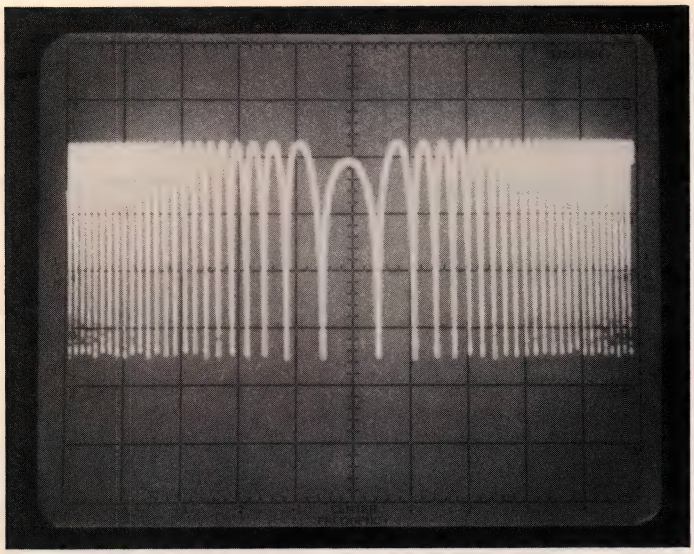


Fig. 9—Use a beat technique to eliminate tracking error. Add the unknown signal and a TG output of about the same amplitude at the SA's input. Observe the beat, magnify the display and manually tune to the center of the beat. Then count the output frequency of the TG.

equal to:

$$t = \text{propagation time} \times \frac{\text{frequency span/div.}}{\text{scan time/div.}}$$

The SA will tune to the acoustic wave as it is reflected back to the input.

Also make certain that system sweep speed is slow enough to accommodate the response time of the DUT **(Fig. 6).** Even though analyzer controls indicate that the sweep speed will indeed allow the system's internal filters to respond, the DUT could have a very narrow-band response or resonance that requires even slower sweeping to be detected. To be sure you're seeing the DUT's true response, then, the sweep speed should be reduced to the point where the shape of the response stops changing.

Improve frequency accuracy

When narrow-bandwidth frequency measurements are required, the TG opens up a few decades' worth of improvement **(Fig. 7).** On a 100-MHz SA with 10-Hz minimum resolution, for example, the addition of a tracking generator can improve frequency-measurement accuracy from ±1 MHz to ±1 Hz—a million-to-one improvement!

A counter obtains these frequency measurements. If the counter is external to the TG, the analyzer must be manually tuned to the signal peak in order for the TG to output the CW signal to be counted. But if the counter is built-in, it typically measures the frequency at which the SA's tunable marker is placed. The user positions the marker on the signal peak to be measured **(Fig. 8);** when sweep reaches the marker frequency, it pauses, TG output is counted and the sweep resumes.

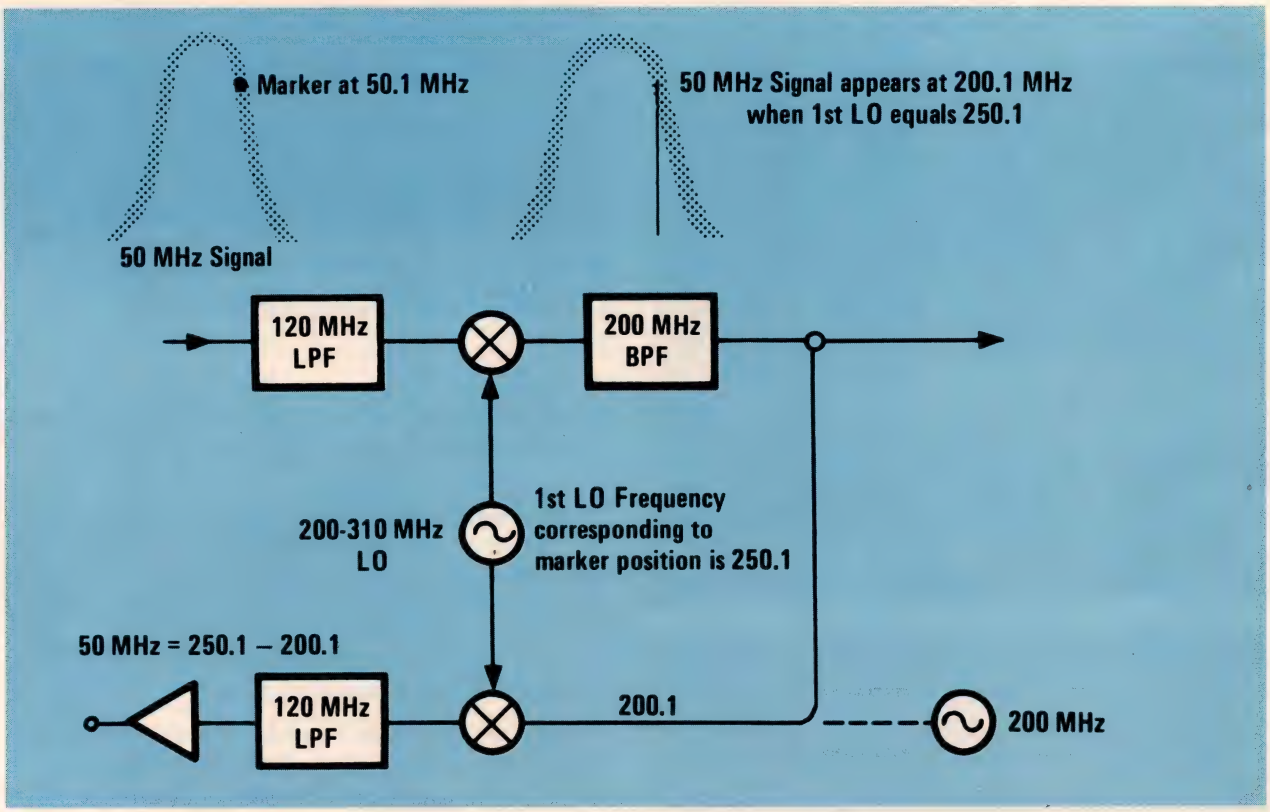


Fig. 10—With a restore mode feature, the TG outputs the center frequency of a signal response as long as the analyzer's marker is tuned somewhere on the skirt of the response.

MANUFACTURERS AND SPECIFICATIONS OF AVAILABLE TRACKING GENERATORS

		AILTECH	ANRITSU	HEWLETT-PACKARD				MARCONI	TAKEDA-RIKEN	TEKTRONIX			TEXSCAN
		707-25	MH628A	3580A	8443A	8444A*	8556A	TF2370	TR4151	5L4N	TR501	TR502	9650NF
FREQUENCY RANGE (MHz)		0-4000	0.1-1700	5 Hz-50 kHz	0.1-110	0.5-1250	20 Hz-300 kHz	30 Hz-110 MHz	0.1-1500	0.02-20 kHz OR 0.1-100 kHz	0.1-1800	0.1-1800	1-350
OUTPUT	RANGE (dBm)	0 to −60	0 to −60	0.2V RMS (600Ω)	+10 to −120	0 to −10	0.1-3V (600Ω)	−10	+5 to −35	−46 dBV (600Ω)	0 to −11	0 to −59	NS
	STEPS (dB)	10	1, VERNIER	NS	1, VERNIER	VERNIER	VARIABLE	NS	10, VERNIER	VARIABLE	1, VERNIER	1, VERNIER	NS
FLATNESS (dB)		NS	NS	±3%	±0.5	±0.5	±0.25	±1.0	NS	±0.2	±3.0	±2.0	NS
DYNAMIC RANGE (dB)		>110	120	80	130	>90	140	120	NS	80	>100	>110	NS
COUNTER		EXT	EXT	EXT	INT	EXT	EXT	INT	EXT	EXT	EXT	EXT	EXT
TIME-BASE STABILITY		NA	NA	NA	$<3 \times 10^{9}$/DAY	NA	NA	2×10^{8}/DAY	NA	NA	NA	NA	NA
FREQUENCY MARKER	AVAILABLE	NO	NO	NO	YES	NO	NO	YES	NO	NO	NO	YES	YES
	TUNABLE	NA	NA	NA	YES	NA	NA	YES	NA	NA	NA	CF ONLY	NO
STAND-ALONE/INTEGRATED		SA	SA	INTG	SA	SA	INTG	INTG	SA	SA	PLUG-IN	PLUG-IN	INTG
PRICE		$4200	$3800	BUILT-IN	$4300	$3400	BUILT-IN	BUILT-IN	BUILT-IN	BUILT-IN	$3500	$4500	BUILT-IN

NS: NOT SPECIFIED
NA: NOT APPLICABLE
*ALSO COMPATIBLE WITH NELSON-ROSS 600 SERIES

Avoid tracking errors

Error in frequency measurement is the sum of counter error (usually ±1 digit), source-residual FM and tracking error. The tracking error component is the difference between the output frequency of the TG and the tune frequency of the SA. It results from the generator's incomplete duplication of the analyzer's conversion process, and causes both frequency-measurement error and a shift in the position of a swept response on the analyzer's CRT.

Two methods can overcome tracking error. One is to connect the TG output directly to the SA input; then turn the "tracking adjustment" on the front panel of the tracking generator until the response amplitude of the TG's internal local oscillator, as displayed by the SA's CRT, peaks.

Another method uses a beat technique **(Fig. 9).** This procedure combines the tracking signal with the signal to be measured, resulting in an easily discernible beat. You expand the display and tune to the center of the beat, at which time the source frequency is counted.

Restore mode reduces the human factor

One additional feature, a restore mode **(Fig. 10),** appears on the HP 8443A. This restore mode reduces operator tuning error. It allows the tracking generator to output the center frequency of a signal response, even if the spectrum analyzer's marker is tuned to a point on the skirt of the response. The restore mode achieves this by using the final IF of the SA rather than its internal local oscillator as the starting point of the up-conversion process.

The tracking generator has become a very useful addition to spectrum-analysis instrumentation, but it, too, has its limitations. TG's can be built commercially up to 2 GHz; after that, complications occur: Above 2 GHz, making a TG involves phase-locking a sweep oscillator to the analyzer's IF and requires an external reference oscillator plus a phase-lock synchronizer. A fair amount of tweaking is also needed, but you can make 2 CHz scan to 18 GHz with typically a 45-dB measurement range. □

Reference

1. Application Note 150-3, "Swept Frequency Measurements and Selective Frequency Counting with a Tracking Generator," Hewlett-Packard. (Available by writing directly to HP at 1501 Page Mill Rd., Palo Alto, CA 94304, or circling reader service number 320 *.)*

Author's biography



Peter Linden, Hewlett-Packard spectrum-analyzer marketing engineer in Santa Rosa, CA, is involved with applications engineering and product-line management. Pete received his BSEE and MBA from Stanford University, and spends his leisure hours keeping current in business, reading classical literature and pursuing creative photography and painting.

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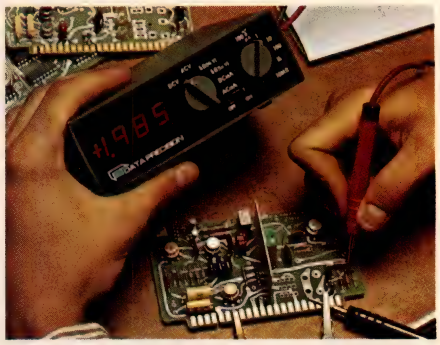


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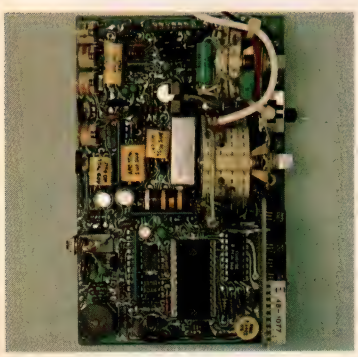


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The competition just isn't competitive

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	Data Precision Model 175	HP 3435	HP 3176B	Fluke 8000A	Fluke 8030
Digits	3½	3½	3½	3½	3½
Size	34 cu. in.	395 cu. in.	123 cu. in.	212.5 cu. in.	69.8 cu. in.
Display Size	0.43″ LED	0.30″ LED	0.25″ LED	0.25″ LED	0.33″ LED
Basic Accuracy for 1 Year ±1 Digit	0.1%	0.1%	0.3%	0.1%	0.1%
DCV Sensitivity	100μV	100μV	100μV	100μV	100μV
AC Frequency Response	30Hz-50kHz	30Hz-100kHz	45Hz-10kHz	45Hz-20kHz	45Hz-10kHz*
Functions	6	5	5	5	6
Ranges	32	27	19	26	26
Hi/Lo Excitation	Yes	No	No	No	No
Calibration Accuracy Guaranteed	1 year	1 year	1 year	1 year	1 year
Overrange	100%	100%	10%	100%	100%
Ranging	Manual	Manual & Auto (except current)	Auto	Manual	Manual
Rechargeable	Yes	Yes	Yes	Optional ($50.00)	Optional ($40.00)
Recharges Batteries While Operating	Yes	Yes	No	Optional	Optional
Full Scale Voltage Drop Measuring Current	100 millivolts (EIA STANDARD)	220-400 millivolts	100 millivolts	100 millivolts	250 millivolts
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Test your data-acquisition system IQ

Although you're familiar with multiplexers, sample/hold's and A/D's, could you apply a DAS module to build a system that works?

Fred Molinari and **Aaron Fishman,** Data Translation, Inc.

An evolutionary product, the data-acquisition system (DAS) module combines a multiplexer, differential amplifier, sample/hold amplifier, A/D amplifier and timing and control circuitry **(Figs. 1 and 2).** It performs the same function that previously required an array of modules and IC's, plus numerous external active and passive components and a pc board. Although each element in the DAS module still has its own characteristics, the manufacturer optimizes the performance mix for the overall data-acquisition function, thus giving users a new set of application parameters to consider.

The questions in this quiz reflect the most common DAS queries received by our application engineers. We make no bones about it—these questions are tough! To score well you must know the details of the data-acquisition function, as well as have some knowledge of the application of DAS modules to microcomputers.

Before turning you loose on the questions, however, we point out that this is an open-book learning experience. Therefore, a list of references appears at the end of this test. The answers themselves, complete with explanations, appear on pgs.83-84.

Pencils ready? Begin!

1. The input impedance of most data-acquisition modules is > 100 MΩ in parallel with 20 pF to ground. What maximum source impedance can be used while still maintaining 12-bit accuracy, assuming a system throughput of 100,000 channels/sec?

a. 100 MΩ

b. 50 MΩ

c. 5 kΩ

d. 100 kΩ

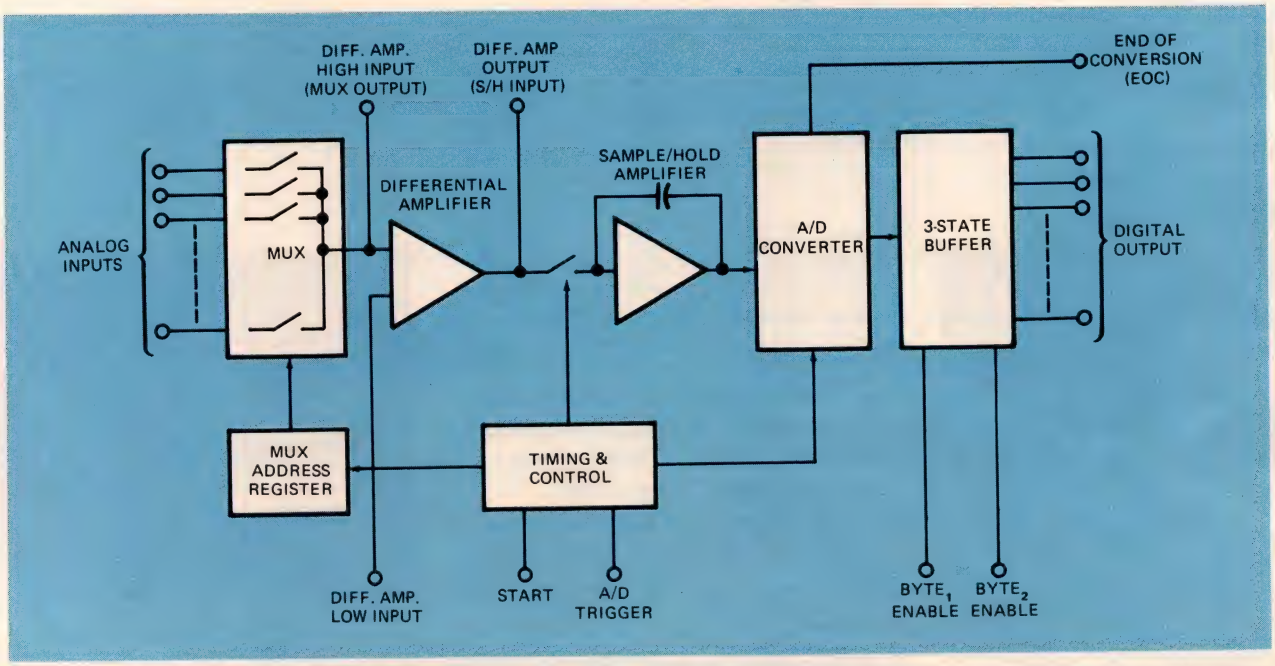


Fig. 1—A typical DAS module contains many elements. Most designers building a data-acquisition system from individual building blocks tend to overspecify the components to be on the "safe" side. DAS-module manufacturers, considering the overall acquisition function and knowing the possible trade-offs, produce plug-in systems that usually cost less.

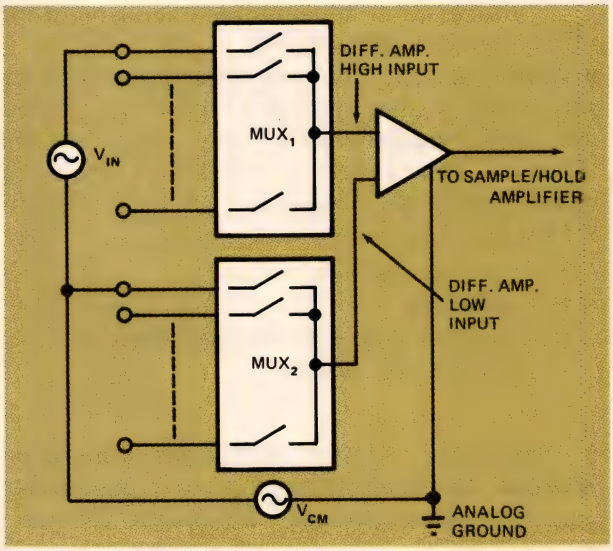


Fig. 2—A differential multiplexer configuration is required if small signals must be measured in the presence of common-mode voltages. However, most DAS modules give the user the option of switching to single-ended operations (see **Fig. 3** and **Quest. 2**).

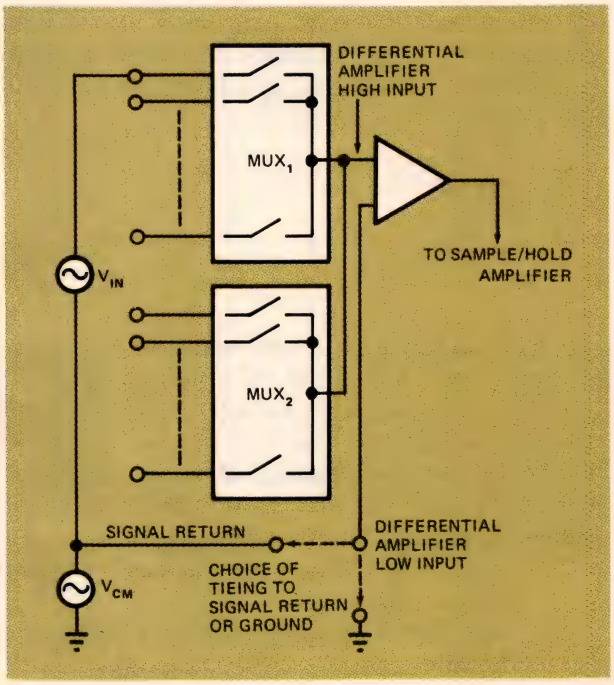


Fig. 3—If your signal sources can operate as single-ended, you can double the number of input channels on most DAS modules. However, what is the best way to connect the low side of the differential amplifier?

2. When a data-acquisition module is configured for single-ended input channels **(Fig. 3),** can the front end still reject common-mode voltages?

a. No, because the differential-amplifier low side is grounded
b. Yes, but all signal-source commons must tie to the differential amplifier's low input
c. Yes, but all signal-source commons must be tied together
d. All of the above

3. A 12-bit data-acquisition module has a 100-kHz throughput and a ±10V input range. What maximum-input slew rate can it digitize to 12-bit accuracy?

a. 0.488 mV/μsec
b. 1 V/μsec
c. 4.88 mV/μsec
d. 10 V/μsec

4. To provide the user with a wider input-voltage range, DAS-module manufacturers often add a switchable-gain amplifier to the front end. Where is the best place to add this amplifier to maintain system accuracy?

a. Between the S/H output and the A/D input
b. Between the differential-amplifier output and the S/H input
c. Between the multiplexer output and the differential-amplifier input
d. None of the above

5. When does the sample/hold actually switch the HOLD mode in a DAS module?

a. When switching to a new channel
b. At the end of a conversion
c. When the A/D converter is triggered
d. From 20 to 230 nsec after the A/D is triggered

6. If a given data-acquisition module has a throughput of 100,000 channels/sec, how can a greater throughput be attained?

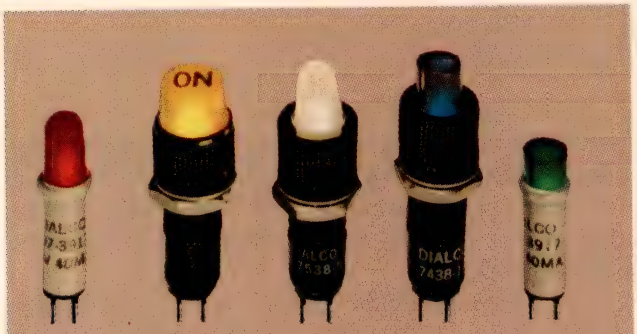
a. By lowering the resolution of the A/D
b. By sampling the next channel during the conversion of the previous channel
c. By speeding up the A/D clock and lowering the sample period
d. All of the above

7. Data-acquisition modules usually have 3-state outputs for direct connection to μC busses. However, how can a 12-bit DAS module be connected to an 8-bit μC, such as the 8080A or the 6800?

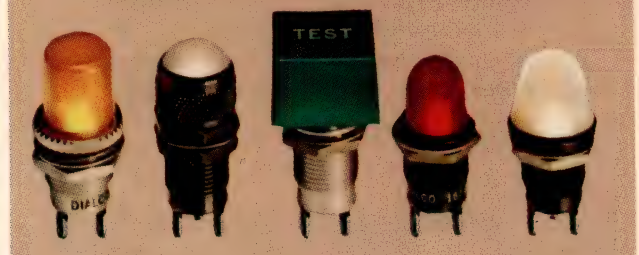
a. It can't. You must use a 16-bit μC like the IMP/PACE, the 9900, the LSI-11 or the microNova
b. No problem, you need only a storage register to hold the extra four bits while the first eight bits are entered into memory
c. Simply by enabling the first byte for bits 5-12 (LSB) for the first instruction of the 2-word transfer; then enabling the second byte for bits 1-4 (MSB)
d. You need two μC chips tied in a multi-

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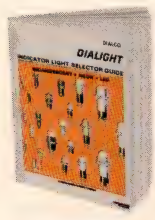
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processor arrangement to handle eight and four bits, respectively

8. Let's assume you are interfacing a data-acquisition system module to the 8080A μC, but you are undecided about the design of the interface. Your system is real-time with several other peripherals, including discs and a teletype. Which interface design should you use?

a. Program control
b. Interrupt
c. Memory map without interrupt
d. None of the above

9. You have a 12-bit data-acquisition system module interfaced to an 8-bit microcomputer. The μC takes an average of 3 μsec to execute a memory or an I/O instruction, while the DAS module specs a throughput time of 10 μsec. What is the throughput time of the analog-input system? (Assume that channel selection and start conversion are accomplished with one I/O instruction and that one instruction also accomplishes a test for A/D DONE. We define throughput time here as the time needed to get data from the DAS module to memory.)

a. 31 μsec
b. 100 μsec
c. 56 μsec
d. 10 μsec

10. You can buy a 12-bit DAS module with 3-state outputs and 16-channel (differential) capability for $175. However, assume you need 64 channels total to digitize the 64 sensors in your system. An expander module offering 48 additional inputs can be purchased for $450. Which workable approach proves the most cost-effective?

a. Use four DAS modules and bus the 3-state outputs together
b. Use one DAS module with an expander module
c. Neither approach is recommended. □

References

1. Tatro, Richard D. and Calkins, Robert, "Are you getting the most from newer data-acquisition systems?", EDN, September 5, 1975, pgs. 61-65.
2. Brodie, Dean, "Test your data-conversion IQ," EDN, May 20, 1975, pgs. 39, 40, 67 and 68.
3. Sheingold, Daniel H., Editor, Analog-digital conversion handbook, Analog Devices Inc., Norwood, MA.

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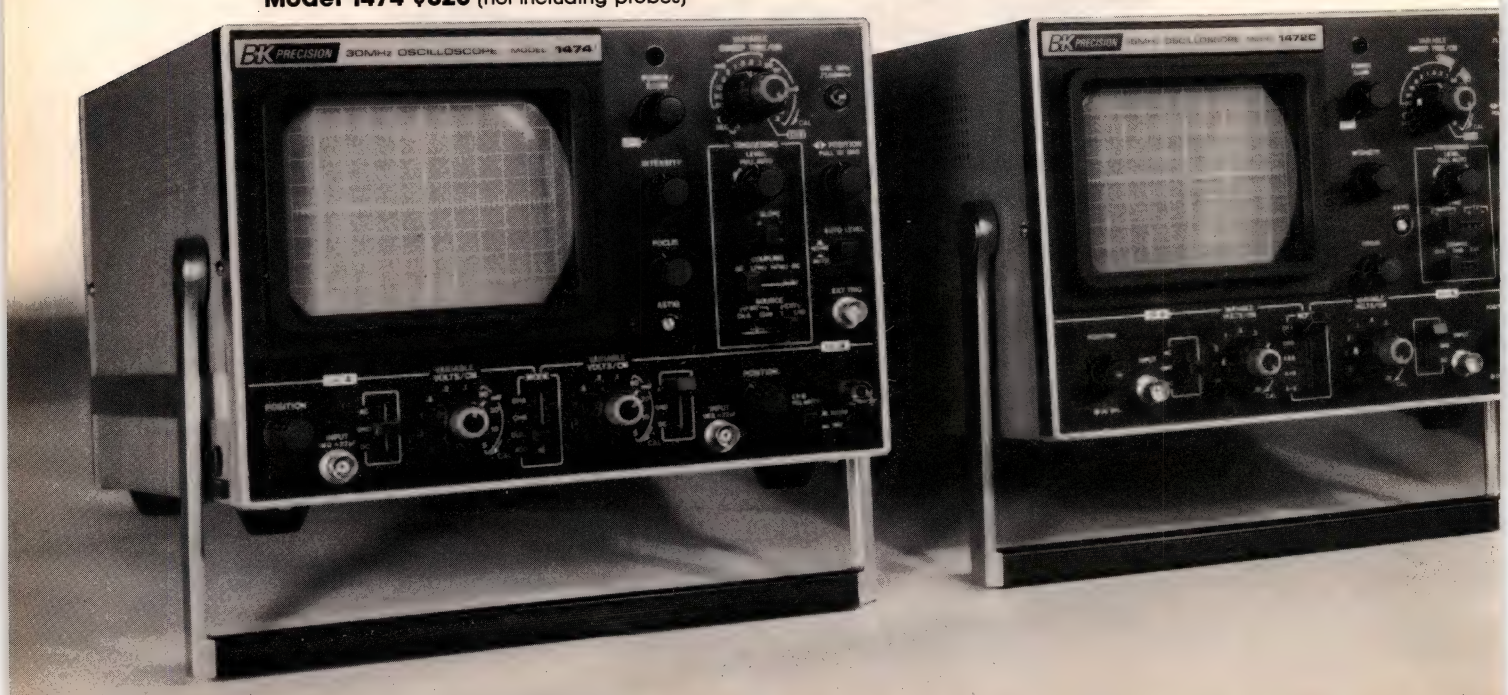
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Filter chokes and linear inductors—the design rules differ

Linear-inductor design emphasizes inductance stability; but design for power-supply filter chokes may call for variable inductance.

Robert Miller, Bourns, Inc.; **Dr. A. Kusko** and **Thorleif Knutrud,** Alexander Kusko, Inc.

Because input filter chokes help reduce stresses on associated components, they play a part in many power-supply designs: Their use avoids the excessive peak currents typical of capacitor-input filters, easing the job of the power transformer, rectifier and filter capacitor.

Selection of an input filter choke is a straightforward process. Three parameters must be known and specified—the dc winding resistance, the dc current and the inductance. Choke size automatically follows, with little room available for trade-offs.

Specifying an input filter choke

In **Fig. 1,** the allowable voltage drop sets the choke resistance, R, at max. current, I_d. For miniature chokes, the L/R ratio typically lies in the range from 0.02 to 0.2; while for microminiature chokes, a ratio of 0.002 to 0.02 is more common. Winding resistance and voltage drop can be traded off against size, but additional voltage drop in the choke calls for increased transformer voltage and size, and requires greater regulator range in the power supply.

Choke inductance, L, should be selected to maintain continuous current at the min. dc choke current, I_1. For currents less than I_1, the capacitor voltage will rise toward the peak ac value as shown in **Fig. 2,** while for currents greater than I_1, capacitor voltage follows the IR drop of the choke and transformer windings.

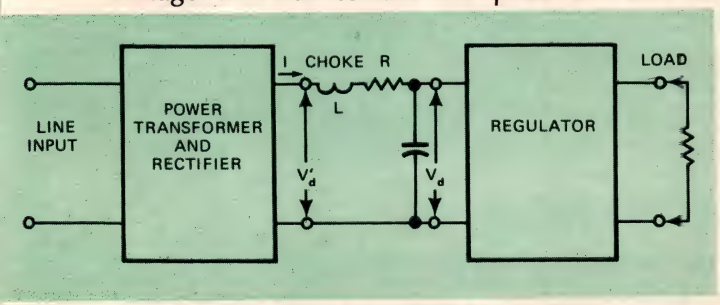


Fig. 1—In a choke-input filter, the choke cushions associated components from excessive peak currents.

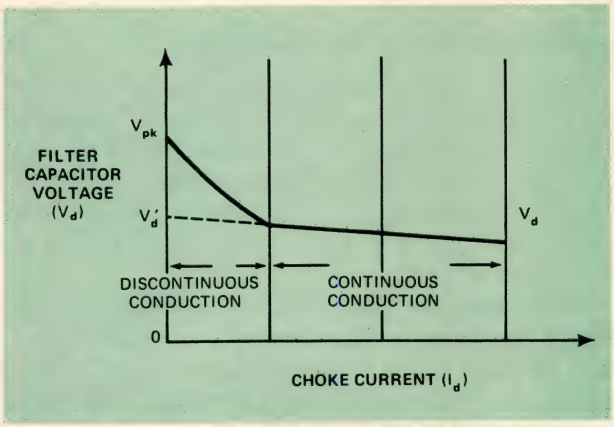


Fig. 2—Filter-capacitor voltage, as shown, varies as a function of choke current. Note the rise when conduction occurs for <100% of the time.

V'_d, the average rectifier voltage, is expressed by: $V'_d = V_d + I_dR$. **Fig. 3** shows the choke-current waveform at I_1, the point at which conduction becomes continuous. Here the peak ripple current, mainly second harmonic, equals I_1. By equating these two currents, the min. inductance can be calculated as: $L = 0.67V'_d/2\omega_o I_1$.

The filter-capacitor/input-choke combination attenuates the ripple voltage. Capacitor reactance at the second harmonic is usually <0.1 of the apparent load resistance, and <0.01 of the choke reactance. Consequently, the attenuated peak-ripple voltage $\sim 0.67V'_dX_c/X_L = 0.67V'_d/4\omega_o^2LC$.

Increasing the capacitance to reduce ripple voltage has a practical limit. Beyond that point, the resistance of the capacitor becomes significant. One result of appreciable capacitor resistance is that ripple current can cause overheating. Obviously, though, L and C can be larger than the

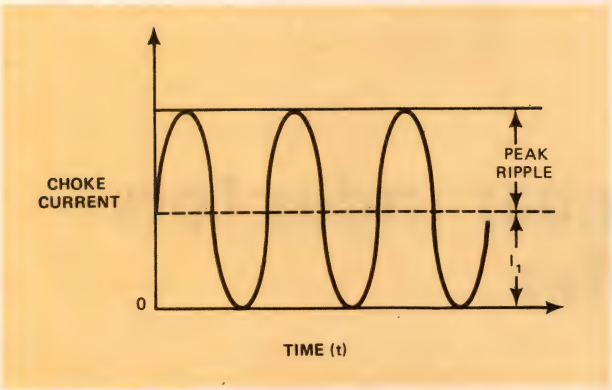


Fig. 3—Choke current is shown at the onset of continuous conduction. Here the peak ripple equals I_1.

calculated values. Both can be traded off to allow the use of standard sizes and achieve best overall performance and cost.

Input-choke design considerations

Basically, an input choke consists of a magnetic core with air gaps and a winding. The choke inductance opposes ripple, while the dc passes through without attenuation except for the IR drop. Air gaps counter dc ampere turns, and are selected to bias the core up to about 15 kG at max. load current, I_d.

Absorption of the ac ripple voltage by the choke produces in the core an ac component of flux density with an amplitude up to a few kilogauss, superimposed on the dc level. The choke should be designed with the least material that will satisfy the requirements of L, R and I_d.

Inductance, expressed in English units, is given by $L = 3.19N^2A_g \times 10^{-8}/(l_g + l_c/\mu\Delta)H$, where N = turns; A_g = gap area; l_g = gap length; l_c = core length; $\mu\Delta$ = incremental relative permeability.

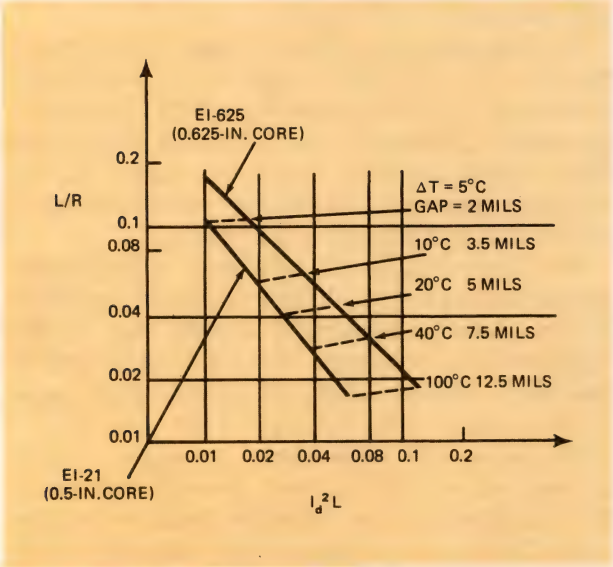


Fig. 4—Choke characteristics displayed are for two sizes of cores employing square-section E-1 laminations.

Reducing the gap, l_g, allows the bias flux density to rise and the incremental permeability, $\mu\Delta$, to decline; and the choke finally reaches a max. inductance for the core. The selection of the core actually sets an energy value of I_d^2L for a given time constant, L/R. The designer then selects the turns, N, and the gap, l_g, to obtain specific values of L, I_d, and R.

Two core sizes—two sets of capabilities

Fig. 4 shows the interaction of the parameters for two core sizes of miniature chokes. To move on the chart, the designer varies the gap dimension, current loading of the wire, and/or turns. The same core can be applied over a 10:1 range of energy by accepting a 1:10 range of resistance and corresponding temperature rise. It is important to tie down the design by specifying all three parameters, as the curves show.

When a choke is miniaturized, the energy I_d^2L at a given L/R is proportional to the core volume. Core volume of the EI-21 in **Fig. 4** is about half that of the EI-625, so the EI-21 can provide about half of the I_d^2L. For a specification of two parameters, I_d and L, or I_d^2L, the designer can miniaturize the choke only by accepting a higher R.

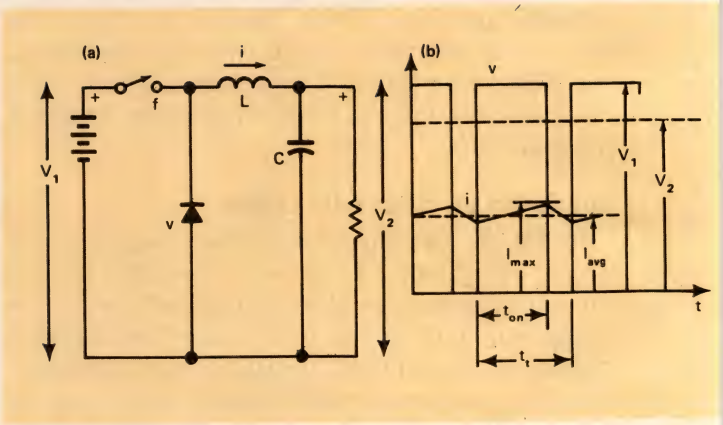


Fig. 5—Switching-regulator circuits place different demands on a choke than input-filter usage. This is illustrated by the equivalent circut **(a)**, and voltage/current waveforms **(b)**.

A "swinging" choke can reduce size and cost when operating over a wide current range becomes necessary. This approach provides the inductance, L, needed for continuous conduction at min. load current, I_l. However, the core is allowed to saturate when the max. load current, I_d, is approached, causing $\mu\Delta$ and the inductance to decline. Increasing the filter capacitance, and/or an assist from the regulator, secures adequate ripple attenuation.

Linear inductors—a different breed

Linear inductors provide the stability required for filter and tuned-circuit applications. Practical

linear-inductor designs must take into account the required inductance, operating frequency, desired Q and allowable temperature coefficient. Other factors such as the voltage coefficient may be important for some uses.

Usually, the core material and physical size of the inductor are selected to provide the desired characteristics. Laminations are customarily used up to about 10 kHz; powdered moly-permalloy cores, from 1 kHz to 1 MHz; and ferrite cores, from about 100 kHz to 50 MHz.

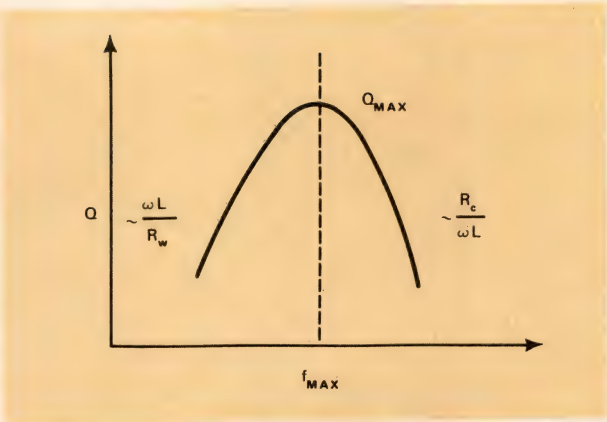


Fig. 6—Linear-inductor Q generally exhibits a frequency characteristic determined by winding resistance and core loss.

As a general rule

A linear inductor (except one with an air core) consists of a winding placed on an air-gapped ferromagnetic or ferrimagnetic core.

All such inductors exhibit max. Q at some frequency, f_{MAX}, and good design dictates that the designer will try to have this coincide with the operating frequency.

As depicted in **Fig. 6,** each downslope from the max. Q is the result of a different type of loss. The ascending portion is caused by the winding-resistance effect (expressed by $\omega L/R_w$), while the descending portion results from the core loss ($R_C/\omega L$). The min. value of Q_{MAX}, f_{MAX}, inductance, and other requirements must be specified. Inductors are either wound on bobbins that are placed on laminated-steel or ferrite-pot cores, or directly on powdered-iron ring cores. Actual or equivalent (powdered-iron) air gaps are provided to (1) insure linearity; i.e., maintain constant inductance as current through the inductor varies; (2) minimize inductance changes that result from variation of material permeability with tempera-

Filter-choke examples

Example 1: 60-Hz line, F.W. rectifier

For the filter of **Fig. 1,** select the input choke and filter capacitor to meet the following requirements: V_d = 15V; I_d = 0.02 to 0.2A; I_dR = 2V, max.; and 120-Hz ripple = 100 mV peak.

Choke inductance must at least equal the value determined by: $L = 0.67\ V'_d/2\omega_o I_1 = 0.67\times17/2\times377\times0.02 =$ 750 mH.

Resistance must not exceed: $R = I_dR/I_d = 2/0.2 = 10\Omega$. From these, we see that the L/R ratio is 0.075 and the I_d^2L is 0.03.

As **Fig. 4** shows, the requirement can be met with an EI-625 structure and a total air gap of 3.5 mils. Calculations show that N = 600 turns of No. 27 wire.

Capacitor size for the specified ripple is given by: $C = 0.67\ V'_d/4\omega_o^2L\times$(ripple volts) $= 0.67\times17/(4\times 377^2\times0.75\times0.1) =$ 268 μF.

Example 2: Choke size vs. circuit

Compare the choke size for full-wave vs. half-wave 400-Hz single-phase rectifier circuits. Assume V_d = 5V; I_d = 0.15 to 1.0A; and I_dR = 1.0V.

For full-wave rectification: $L = 0.67\ V'_d/2\omega_o I_1 = 0.67\times6/2\times2\pi\times400\times0.15 =$ 5.3 mH; $I_d^2L =$ 0.005; $R = I_dR/I_d = 1\Omega$; and L/R = 0.005. A typical commercial bulletin shows that such a choke will have overall dimensions of about 1×1×0.5 in., or 0.5 in.^{3}.

For half-wave rectification: $L = 2V'_d/\omega_o I_2 = 2\times6/2\pi\times400\times0.15 =$ 38 mH; $I_d^2L = 0.038$; $R = 1\Omega$; and L/R = 0.038. **Fig. 4** indicates choke dimensions of about 1.5×1.25×1.25 in., or 2.34 in.^{3}—five times larger than for full-wave.

Example 3: Choke for switching regulator

Fig. 5a shows the equivalent circuit of a power-supply series switching regulator. The switch (usually a transistor) operates at some frequency, f, with the ON and OFF times (t_{ON} and t_{OFF}) adjusted to regulate the output voltage, V_2, to a required value in the face of input voltage (V_1) variation.

Typical current and voltage waveforms are given in **Fig. 5b.** Find the required choke inductance, L, for V_1 = 12 to 16V; V_2 = 10V, f = 10 kHz, I_{AVG} = 1A and I_{MAX} = 1.1A.

Current rise during the ON time is given by: $(V_{MAX} - V_2) \times t_{ON}/L = I_{MAX} - I_{MIN} = 2(I_{MAX} - I_{AVG})$. ON time is related to the period t_t by $t_{ON}/t_t = t_Mf = V_2/V_1$. The value of L thus equals: $L = (V_{MAX} - V_2)\ V_2/2fV_1\ (I_{MAX} - I_{AVG}) = (16-10)\ 10/2\times16\ (1.1-1.0) \times 10^4 =$ 1.88 mH. Ripple requirements of the load voltage determine which value of C to use.

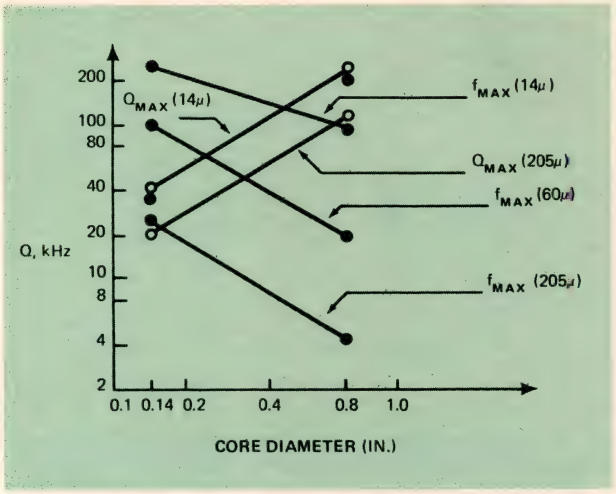


Fig. 7—Powdered-iron core inductors cover wide ranges of both frequency and max. Q, with particle size a major controlling factor.

ture, time and manufacturing; and (3) provide a means for adjusting the inductance.

Practically any desired inductance can be obtained with a given core and its air gap by winding the required number of turns of a suitably sized wire into the winding space. However, the larger the air gap is made in the interest of stability, the more turns will be required for a given inductance, and the lower will be Q_{MAX}.

The parameters Q_{MAX} and f_{MAX} for inductors on powdered moly-permalloy cores from 0.14- to 0.80-in. outside diameter (o.d.) are shown in **Fig. 7.** Q_{MAX} rises linearly with o.d. and is practically independent of particle size (air gap). f_{MAX} declines as 1/o.d., and depends on particle size. The larger the particles, the greater the specific core loss, and the lower the value of f_{MAX}. Note that the turns act like a scale factor on the inductance, L, without affecting the Q_{MAX} and f_{MAX} of a specific core.

Ferrite-core inductors typically cover the inductance and frequency span with 12 sizes of cup cores. These range from 7- to 66-mm o.d., and are made from materials with permeability factor, μ_o, between 125 and 2300. **Fig. 8** shows the Q vs. f of a 26-mm o.d. core inductor for a range of turns that fills the winding space. Q_{MAX} and f_{MAX} decrease as the inductance and number of turns increase (because of winding capacitance).

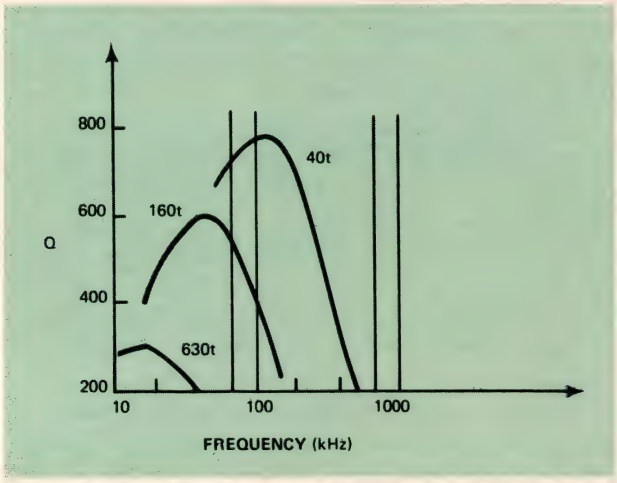


Fig. 8—A typical ferrite cup-core inductor (26-mm o.d.; 1800 μ_o) exhibits the frequency behavior shown.

Ferrite-core inductors are slug-tunable, less expensive to manufacture and less temperature-stable than powdered-iron core inductors. However, ferrites are available for higher frequencies of operation than the ferromagnetic type.

Ferromagnetic-inductor characteristics

Fig. 9a shows a circuit model for a ferromagnetic inductor, consisting of the winding resistance, R_W, the core-loss resistance, R_C, and the inductance, L. This model is reasonably accurate for variations of current and frequency. The core loss

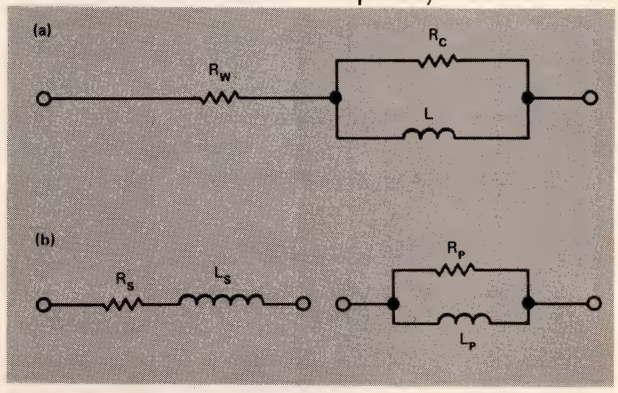


Fig. 9—Ferromagnetic inductors can be modeled as in **(a)**; and, for one operating condition, the series and parallel equivalents shown in **(b)** are valid.

varies as $f^2B_M^2$, corresponding to eddy-current loss. Actual core losses consist of the sum of hysteresis, eddy current, and gap losses.

At any one operating condition, the inductor can be represented by parallel or series equivalent circuits **(Fig. 9b).** The designer can derive equivalent-circuit parameters from the parameters of the model, by the test of the actual inductor and by calculation from the design.

The Q is defined as $\omega L_S/R_S$ or $R_P/\omega L_P$, where R_S and R_P include the effect of both winding and core loss. In terms of the circuit model **(a)** of **Fig. 9,** $1/Q = R_W/\omega L + \omega L/R_c = 1/Q_W + 1/Q_C$, where Q_W represents the "winding" component and Q_C, the "core" component.

In the low-frequency region of **Fig. 6,** the winding resistance, R_W, dominates and the inductor behaves as Q_W. In the high-frequency region, the core loss, R_C, dominates and the inductor behaves as Q_C. Q_{MAX} occurs at f_{MAX} where the Q components are equal ($2\pi f_{MAX} = \sqrt{R_W R_C/L}$), and is 1/2 of either value.

Linear-inductor examples

Example 1: Powdered-iron core inductor

An inductor has L = 0.1H; Q_{MAX} = 20; and f_{MAX} = 30 kHz. Find the components R_W and R_C, and the Q at f = 10 kHz.

The resistance components are given by $Q_{MAX} = 0.5 \times 2\pi f_{MAX}\ L/R_W$; $R_W = \pi \times 3 \times 10^4 \times 0.1/20 = 465\Omega$; $R_C = 4\ Q_{MAX}^2 \times R_w = 4 \times 400 \times 465 =$ 0.745 MΩ.

Similarly, the Q (at 10 kHz), can be derivec from a knowledge of Q_w and Q_C. $Q_W = \omega L/R_W = 40 \times 10$ kHz/30 kHz = 13.3. $Q_C = R_C/\omega L = 40 \times 30$ kHz/10 kHz = 120. $Q = Q_W Q_C/(Q_W+Q_C) = 13.3 \times 120/(13.3+ 120) =$ 12.

Example 2: Ferrite vs. powdered-iron core

Compare the Q_{MAX} and f_{MAX} of 6.5-mH inductors wound on a 26-mm o.d. ferrite cup core and on an 0.8-in. o.d. powdered-iron core.

First, we'll consider the ferrite cup core **Fig. 8** shows curves that represent a 26-mm core with an inductance factor A_L = 250 mH/1000t, or μe = 80.5. For 6.5 mH, the required turns are: $N = 10^3\sqrt{6.5/250} =$ 160t. Then for N = 160t, Q_{MAX} = 600 and f_{MAX} = 60 kHz.

For the powdered-iron core unit, the curves in **Fig. 7** show that a comparable inductor will use a 14μ core. In this case, the inductance factor, A_L, = 7.8 mH/1000t, and N $= 10^3\sqrt{6.5/7.8} =$ 915t. Q_{MAX} = 150, and f_{MAX} = 60 kHz, taking into account the 25-pF distributed capacitance, C_d, of the winding (f_o = 400 kHz).

For a given ferromagnetic core material, the upper-frequency (descending) part of the Q curve of **Fig. 6** is independent of the size (geometry), but dependent upon the material. In the lower-frequency (ascending) part, the curve depends upon the winding resistance and the $Q_W \sim l^2$ (l = linear dimension). As the inductor size is reduced, (l < 1), the Q curves behave as shown in **Fig. 10;** Q_{MAX} decreases as l, while f_{MAX} increases as 1/l. For thicker laminations or lossier core material, the descending (Q_C) part of the curve moves to the left.

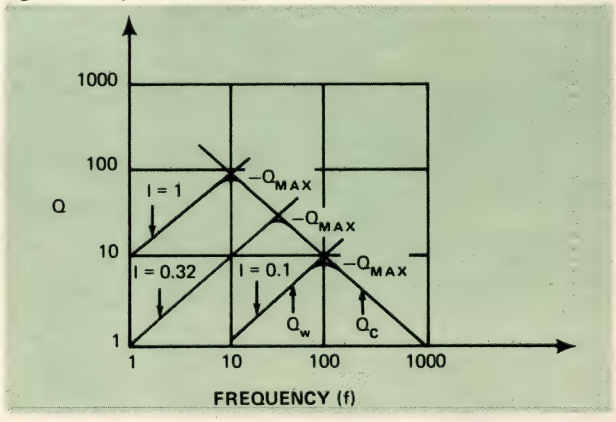


Fig. 10—Ferromagnetic-inductor Q depends on both core and winding losses, shown here for variation of l from 1 to 0.1.

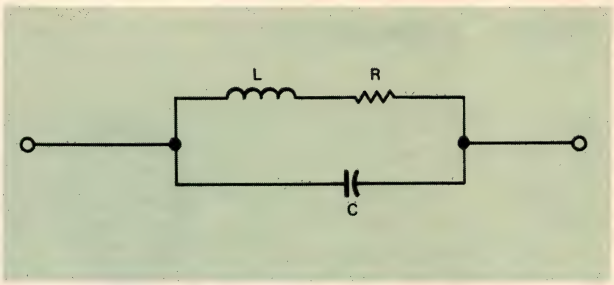


Fig. 11—Ferrite-core inductors can be represented by this simplified equivalent circuit.

Ferrite inductor Q

For ferrite inductors, Q can be expressed as $1/Q = \sum \tan\delta$ where δ represents the individual loss angles between B and H in the core (representing dc winding resistance, eddy currents in the wire, dielectric losses and core losses).

A simplified equivalent circuit is shown in **Fig. 11,** where C represents the interwinding capacitance. The Q is approximately $\omega L/R\ (1-\omega^2/\omega_o^2)$, where ω_o is the resonant frequency of the inductor. The Q will become zero when $\omega = \omega_o$.

As a given core is wound with more turns of smaller wire to increase inductance, the resonant frequency, ω_o, is reduced and the Q curves shift as shown in **Fig. 8.** This same phenomenon occurs in large, high-inductance, powdered-iron inductors. The winding resistance primarily governs the ascending part of the Q curves, which falls on a common locus. □

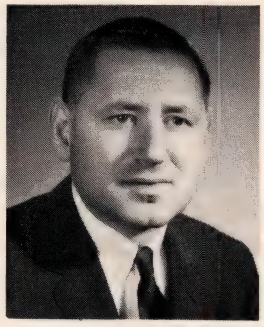
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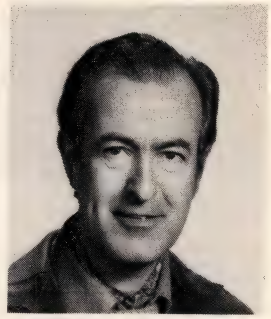
Authors' biographies



Robert Miller, engineering manager of Bourns Magnetic Products, Bourns, Inc., Romoland, CA, has overall responsibility for the design and development of magnetic products. Bob is a graduate of the Univ. of California at Berkeley and enjoys both tennis and golf.



Dr. A. Kusko is president of his own consulting firm, Alexander Kusko, Inc., and is also a lecturer at M.I.T. He received his BSEE from Purdue; his SM and ScD degrees in Electrical Engineering from M.I.T.; and is a member of Sigma Xi, Tau Beta Pi and Eta Kappa Nu. A registered PE, Dr. Kusko holds 14 patents. He reports that this article represents "the culmination of 25 years of consulting and development work on magnetics, including numerous patents, articles and a book."



Thorleif Knutrud has been a senior consultant with Alexander Kusko, Inc. since 1970. He's an M.I.T. graduate (BSEE, MSEE), a member of the IEEE and NIF, and holds two patents. Thor, who has designed and developed magnetic circuits since the early days of magnetic amplifiers, feels certain that magnetic-circuit design still has, and will continue to have, a very important mission in electronics.

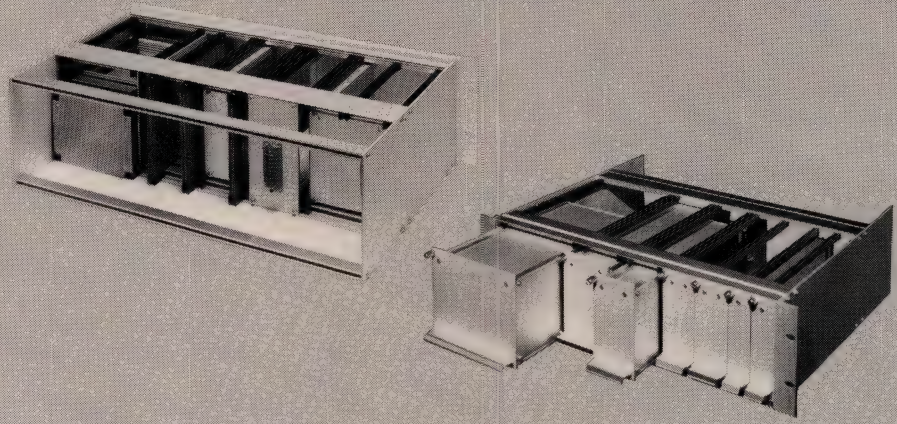
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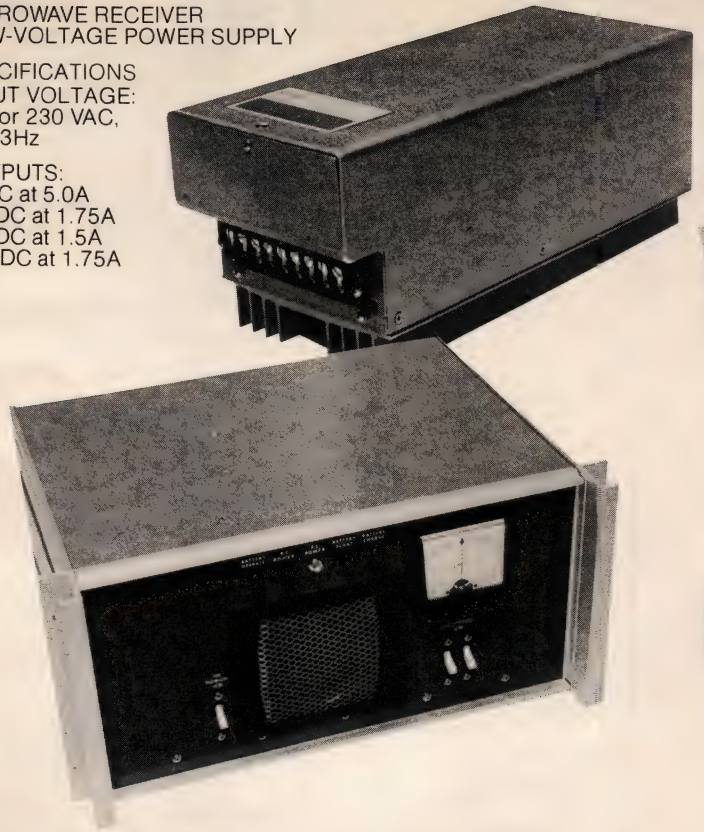
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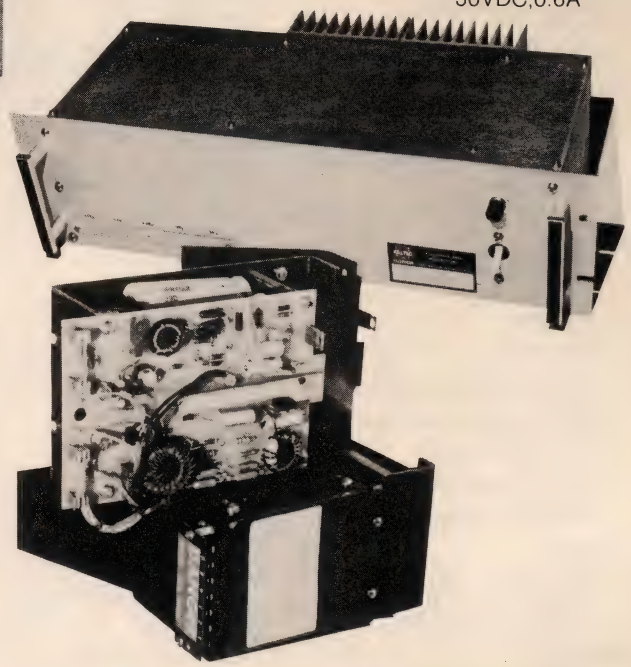
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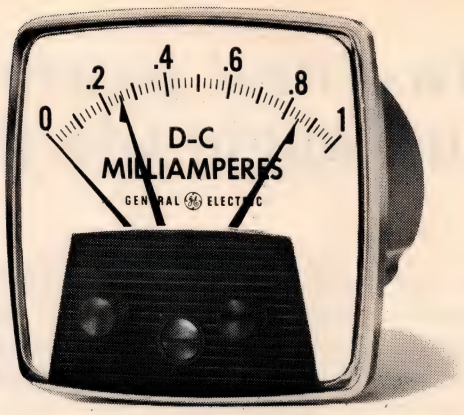
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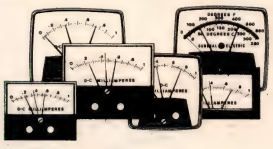
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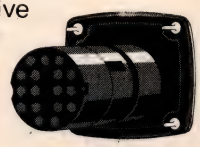
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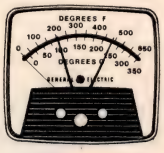


Some manufacturers give you choices . . . such as integral pushbuttons and alarm lights, dc-powered models, low-signal operation using op-amps, and thermocouple break protection (on pyrometers). Evaluate these options carefully for your own product requirements.

. . . Such as GE's unique "piggyback" or remote-mounted controller option. (Get small quantities quickly from your local Mod Center . . . OEM quantities from GE direct.)

6 If you're specifying pyrometers . . .

Be sure it has been designed for maximum accuracy and compatibility with your thermocouple sensors. Pyrometers should provide precise temperature control, over-temperature protection and error-free readings.



GE pyrometers monitor temperature as low as 0-150° F.

7 And don't forget the reputation of the meter relay manufacturer.

Make sure the manufacturer will stand behind his products and that his meter relays meet all ANSI specifications.

For a free guide entitled, "Pick the Right Panel Meter" (GEA-10340) and our complete Catalog (GEP-307), write to General Electric Co., Section 592-67, Schenectady, N.Y. 12345.

Specify General Electric . . . just for good measure.

592-67

GENERAL ELECTRIC

For more information, Circle No. 36

That neat power MOSFET design just might win this design contest

If you have a switching or amplifier application that requires high current, high speed and linearity; or your switching application needs high input impedance and high speed; or you have an idea that uses a medium-power VHF amplifier, then consider yourself a prime candidate for the EDN/Siliconix Design Contest.

Earlier this year, Siliconix announced its VMP family of MOSPOWER™ FET's that prove ideal for the above applications. To find the most innovative and best utilizations of these transistors, Siliconix and EDN Magazine are co-sponsoring this design contest. So put on your thinking cap and get cracking. One of the valuable prizes could be yours!

Here's how to enter

There are several ways to enter the contest. **Circle Reader Service Number 300** and we'll send you an entry kit that includes product data sheets, basic application information, entry blank and rules.

For faster service, go to your nearest Siliconix distributor, sales representative or sales office and pick up a kit; or tear out this page and send it with your business card to the address on the entry blank. Those of you who already have the MOSPOWER™ FET data sheets can bypass all of the above and use the entry blank provided here.

Don't delay! Read the contest rules and take action now. The deadline for entries is midnight, February 15, 1977. Winners will be announced in May and selected winning designs published by EDN in June 1977.

There's a **bonus for RF designers,** too. If your RF design scores among the top five winners, you'll receive an extra prize shown on the prize list.

Give your friendly local distributor a break! Include his name on your entry and we'll send him a duplicate prize. You'll move right to the top of his "good-guy list."

Circle R.S. No. 300 to receive your entry kit.



FIRST PRIZE: Black & Decker power tools

SECOND PRIZE: Microma watches

SIXTH—TENTH PRIZES: Digital stopwatch

CONTEST PRIZES:

First Prize (value $850)

Black & Decker power tool assortment consisting of:

- Variable-speed jig saw kit
- 2-speed dustless belt sander
- 7-1/4-in. deluxe circular saw
- 10-in. power shop with cabinet
- 8-gal. wet/dry vacuum cleaner
- Router kit
- 5-in. bench grinder
- 21-piece twist drill-bit set
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Third Prize (value $100)

Black & Decker power tool assortment consisting of:

- Variable-speed jig saw kit
- 7-1/4-in. deluxe circular saw

Fourth and Fifth Prizes (value $75 for each prize)

- Two (2) smoke detectors

Sixth-Tenth Prizes (value $50 for each prize)

- Siliconix hand-held electronic digital stopwatch

RF BONUS PRIZE (value $100)

A bonus prize will be awarded to the best RF application submitted if judged among the top five (5) entries. This prize will be a Black & Decker power tool assortment consisting of:

- 3/8-in. variable-speed drill kit
- Finishing sander kit
- 100-ft 16-gauge, 3-wire extension cord

TOTAL PRIZE VALUE = $1600

CONTEST RULES:

1. Prizes will be awarded for best utilizations of VMP MOSPOWER™ FET features. A bonus prize will also be awarded for the best RF application if judged among the top five entries.
2. A signed entry blank must accompany all entries.
3. All entries must describe in detail the utility of the design, how it works and benefits to be gained from its use. They must also include a block diagram and/or circuit schematic of the system.
4. Designs must not contain confidential or proprietary information.
5. Entries must be postmarked no later than midnight, February 15, 1977.
6. Entries must be conceived and written by entrant(s) and must not have been published previously (limited-distribution house publications excepted).
7. Contestant agrees that the design submitted may be published by Siliconix and Cahners Publishing Company and shall become the sole property of Siliconix.
8. Employees and relations of Siliconix, Cahners Publishing Company and their agencies are not eligible to enter this contest. Consultation with any of the above is prohibited.
9. Judging will be done by Siliconix and EDN.
10. Decisions of the judges are final. In case of duplicate entries, the entry with the earliest postmark wins.
11. Contest is void in states or provinces where prohibited.
12. Mail all entries to:

EDN/Siliconix Design Contest
2201 Laurelwood Road
Santa Clara, CA 95054

EDN/Siliconix Design Contest Date _____

Entry Blank

Name _____ Title _____

Company _____ Division _____

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City _____ State _____ Zip _____

- Name and Function of Your Entry _____

I hereby submit my VMOS circuit design to EDN/Siliconix design contest and agree to abide by all rules herein.

Signature _____



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DRANETZ

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The verdict is in: Solid-state fluorescent ballasts are here

Tradition reigns supreme in the less exotic areas of electronics, so any design breakthrough really is significant!

Robert J. Haver, Motorola, Inc.

Standard 60-Hz fluorescent ballasts have been around for some time. Containing a minimum number of parts, these circuits are simple, reliable, efficient and low cost. With such an array of positive features, the old standard should last forever. Such is not the case, however.

The current-fed oscillator described in this article is the successful result of a program aimed at obtaining an equivalent solid-state fluorescent-lamp ballast. A 20-kHz sine-wave oscillator operating from 120V ac, this device puts out enough voltage to light the bulb and is inherently current-limited after bulb ionization. The circuit is small and quite efficient (90%), and will probably become the "standard" for all arc-lamp ballast work in the future.

The basic circuit **(Fig. 1)** is essentially a class C sine-wave oscillator with a filter choke added to insure more efficient transistor switching. Operating alternately on a 50% duty cycle, the transistors supply power to both the tank circuit (L_1, C_1) and the load resistor, R_L. A feedback winding on L_1 supplies transistor drive and initiates transistor switching when the tank voltage crosses the zero line. Rectifying and filtering the ac line voltage generates the 170V dc circuit supply.

Voltage at the center tap of L_1, with respect to the negative side of the dc supply, is a full-wave rectified sine wave with 170V average value and a peak value of $\pi/2$ times the supply. Since this relationship must be maintained (with no average voltage across L_2), peak tank voltage will always remain equal to π times the supply. If lamp starting requires more voltage, a secondary winding can be added to L_2. Since L_2 ideally has

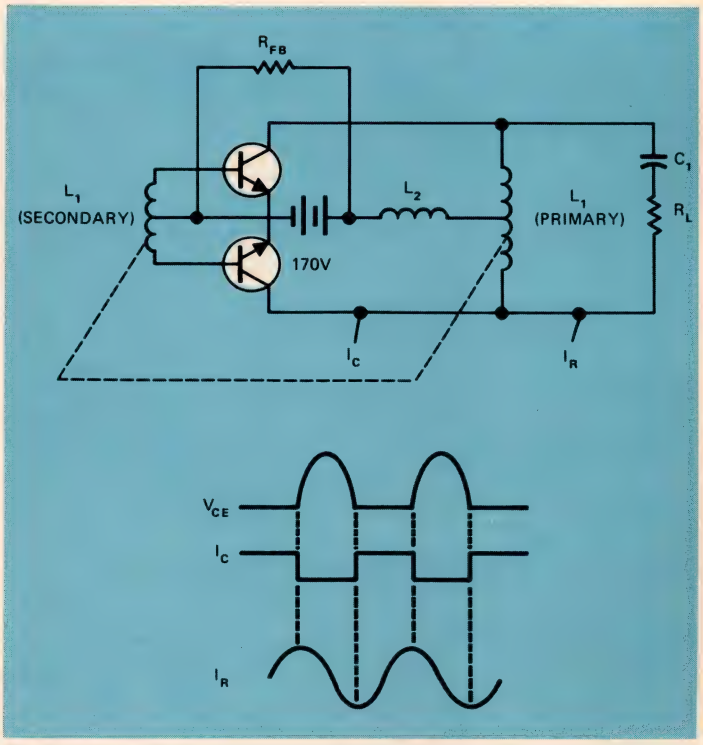


Fig. 1—More efficient transistor switching is insured by adding a filter choke to the class C sine-wave oscillator used in the solid-state ballast design.

infinite inductance, the current through it is constant and dependent on the power dissipated in the load resistor or lamp.

It's time to build on the basics

Two specific applications of the basic circuit are shown in **Figs. 2** and **3.** The circuit of **Fig. 2,** designed specifically for 40W rapid-start bulbs, has a quite straightforward operation.

The ac line voltage is rectified by the MDA922-4 diode bridge and filtered by the capacitor-inductor combination, C_6-L_1. Transistors Q_1 and Q_2, the center-tapped tank coil T_1, and capacitors C_1 through C_3 make up the oscillator's power stage that develops a 600V peak sine wave across T_1. During starting, or when a bulb is burned out or removed, capacitor C_1 acts as a snubber and contains the transistor load line and upper oscillator frequency.

Once the lamps ionize, capacitors C_2 and C_3 lower the tank's operating frequency from 30 to 20 kHz, and also limit the current to each of the bulbs to about 0.4A rms. Because the lamps are in parallel, they operate independently and one

TABLE 1
COIL SPECIFICATIONS

T_{1A} – CENTER TAPPED CHOKE WITH FB WINDING

PRIMARY INDUCTANCE – 2 mH @ 4A (600V @ 20 kHz)
TURNS RATIO – 600V : 60V (PEAK)
FB POWER – 10W

WINDING	CORE
80T =20, 80T =20 : 16T =26	MAGNETICS PERMALLOY POWDER TOROID =55110-A2 (PROGRESSIVE PRIMARY WINDING)
OR	
SEE NOTE 1: 100T, 100T : 20T =26	FERROXCUBE FERRITE E CORE E53/24/14 GAP TO 500 MILS

T_{1B} – CENTER TAPPED CHOKE WITH SECONDARY AND FB WINDING

SECONDARY INDUCTANCE – 2.7 mH @ 4A (1 kV @ 20 kHz)
TURNS RATIO – 600V : 1 kV : 60V (PEAK)
FB POWER – 5W

WINDING	CORE
80T =20, 80T =20 : 260T (SEC) =20	MAGNETICS PERMALLOY POWDER TOROID =55111-A2 (PROGRESSIVE PRIMARY WINDING)
16T (FB) =24	

NOTE 1: BYFILAR WINDING WITH =32/36 LITZ WIRE OR EQUIVALENT

L_{1A} – CHOKE

INDUCTANCE – 4 mH @ 1.7A
(FILTERS 300V, 20-kHz RECTIFIED SINE WAVE)

WINDING	CORE
150T =24	FERROXCUBE FERRITE POT CORE 3019 PL00–3B7 (OR 3C8) GAP TO 100 MILS

L_{1B} – CHOKE

INDUCTANCE – 4 mH @ 2.6A
(FILTERS 300V, 20-kHz RECTIFIED SINE WAVE)

WINDING	CORE
200T =20	FERROXCUBE FERRITE E-E CORE E40/19/12 OR FX3730 (MULLARD) GAP TO 125 MILS

T_{2A} – FB TRANSFORMER

POWER – 10W @ 20 kHz
TURNS RATIO–60V : 6V : 6V : 10V CT (PEAK)

WINDING	CORE
6T =22, 6T =22, 6T =22, 5T =22, 5T =22 : 60T =26	FERROXCUBE FERRITE POT CORE 3019PL00 – 3B7 (OR 3C8) NO GAP

T_{2B} – FB TRANSFORMER

POWER – 5W @ 20 kHz
TURNS RATIO – 60V : 10V CT (PEAK

WINDING	CORE
60T : 5T =22, 5T =22 =24	FERROXCUBE FERRITE POT CORE 2213PL00 – 3B7 (OR 3C8) NO GAP

L_{2A} – STANDARD COIL (SEE FIG. 2)

L_{2B} – CHOKE

INDUCTANCE – 1.5 mH @ 1A
(FILTERS 5V, 20-kHz RECTIFIED SINE WAVE)

WINDING	CORE
80T =24	FERROXCUBE FERRITE POT CORE 2213PL00 – 3B7 (OR 3C8) GAP TO 42 MILS

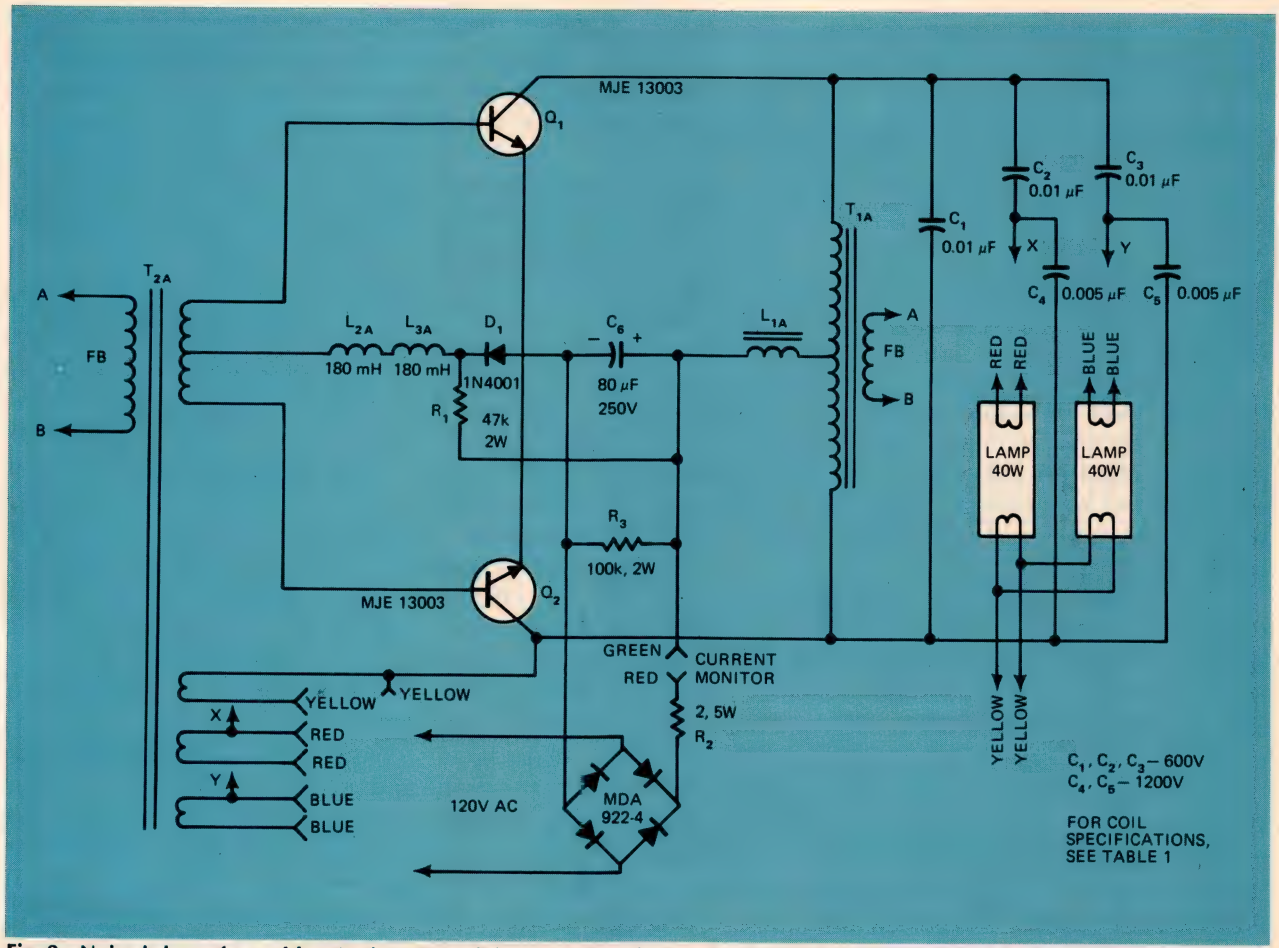


Fig. 2—Noise is less of a problem in this 40W solid-state ballast design. Even though it works at a high frequency, the resonant LC tank circuit produces clean sine waves of power to the lamps.

bulb will remain on if the other is removed. In such a situation, however, both the tank frequency and single bulb current will increase by about 20%.

In this rapid-start ballast design, the feedback transformer (T_2) supplies both transistor base drive and continuous filament power for the lamps. Capacitors C_4 and C_5 limit the open-circuit start-up voltages to 400V and insure a normal rapid-start delay (to allow the filaments to heat) of from 0.8 to 1.4 seconds. (These features are not found in the circuit of **Fig. 3.**) Note that the inductors used in this design for L_2 and L_3 contain about 2Ω of internal series resistance for base-current limiting.

The above operational description also holds for the dual 75W instant-start ballast design of **Fig. 3.** This circuit also operates off the ac line (120V) and uses the same input filter and power stage with one exception—the addition of a secondary winding on T_1. Because these 96-in. instant-start lamps require more starting voltage, the tank-voltage output must be stepped up to 1-kV peak. For most effective snubber action, C_1 is kept on the primary side of the transformer.

Of course, to handle the higher lamp power requirements in this design, most of the components are slightly larger than their 40W counterparts. However, because it does not have to supply any filament power, the feedback transformer is actually smaller.

A few words about component selection

A number of different transformer designs were tried in both ballast types. **Table 1** shows the winding specs for those designs that provided the best operation.

In the case of the 40W ballast, the ferrite E core with Litz wire costs less and is preferred for that reason. Litz wire keeps the losses down but is unfortunately relatively difficult to obtain except in large quantities.

In the 75W ballast design, the low-permeability core selected offers the best compromise on efficiency and cost. All coils were progressive-wound and the turns varied to give the proper amount of secondary inductance for resonance at 20 kHz (about 2.7 mH).

Test observations indicate that the transistors are just coasting in this application and should operate quite reliably. Because of the zero-voltage crossing operating mode, switching losses are practically negligible. Basically, transistor requirements include maintaining saturation when ON and blocking 600V with reverse bias when OFF. A starting transient occurs when the lamps first strike. This momentarily requires the devices to sustain 0.5A at 400V during switching and block 700V.

The 40W ballast requires a 0.5A/800V device; the 75W design, a 1A/800V unit. Switching speeds of 1 μsec are adequate and all devices evaluated met this criterion. However, the units finally selected had exceptional speed (0.5 μsec) and were successfully used without heat sinks in both ballast designs.

For the 40W ballast, the new 715P series of "filmite L" capacitors from Sprague were used for one reason—they cost quite a bit less than their mica counterparts. (As an added feature, they also offer 100°C temperature ratings and high rms current capability.)

While these potential cost savings have also promoted investigation into the possible use of a special high-voltage "filmite L" unit in the 75W ballast circuit, only the mica units from Sangamo presently have adequate voltage ratings for this application.

Rectifier protection is programmed in

Although they tend to draw excessive current from the line, capacitive filters were used in these designs. To minimize these currents, the capacitor values chosen reflect the minimum value consistent with stable circuit operation. However, even with such low-value capacitors, the initial surge currents required to charge these components can still cause input-rectifier failure.

Though viable, a current-limiting scheme based on full-cycle surge-current ratings proves inefficient, costly and rather unnecessary since inrush current flows for such a short time. To avoid these problems, we used a computer program to generate values of limiting resistors for the rectifiers chosen. Based on the RC time constant, the program calculates inrush current pulses and compares this data to the equivalent sub-cycle surge ratings on the rectifiers. Using the I^2t concept, the program repeats the calculations until the correct resistor value is found.

Realistically, it's quite often not possible to use the exact component values generated by computer programs. With conservative design practices, the diode and resistor combinations chosen represent the best compromise of efficiency, cost and form factors in each design. Lower resistor values can be employed with larger rectifiers, but the slight gain in efficiency will not offset the increased cost- and form-factor considerations.

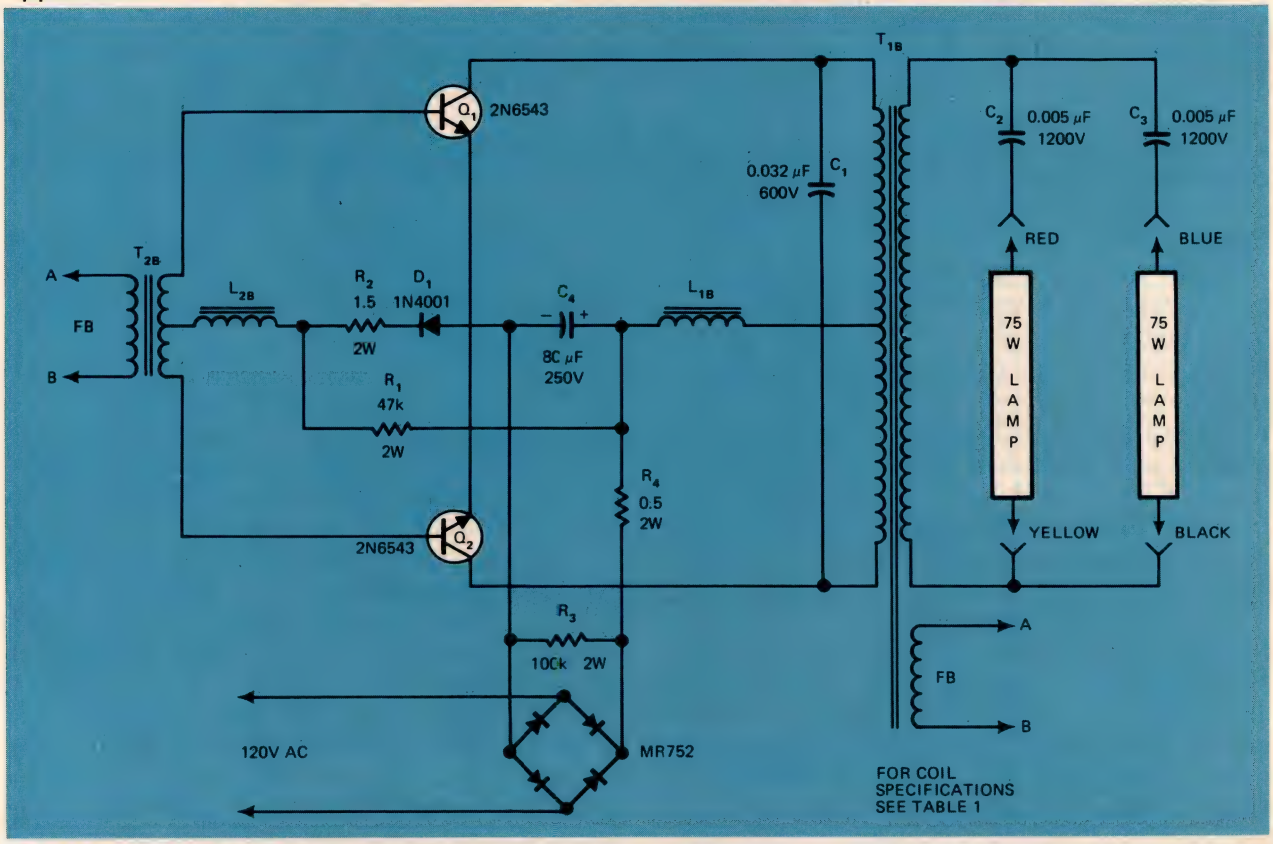


Fig. 3—Higher starting voltages required by most 96-in. instant-start lamps demanded a change in tank-coil design to obtain necessary 1-kV output.

TABLE 2
BALLAST EFFICIENCIES

TEST	DUAL 40 WATT		DUAL 75 WATT	
	STD	SOLID STATE	STD	SOLID STATE
POWER IN (W)	99	83	162	147
POWER OUT (W)	87	74	154	130
APPROX LIGHT OUT (LM)*	6400	6400	12400	12400
EFFICIENCY (%)	88	92	95	88
APPROX EFFICACY (LM/W)	74	87	81	95
POWER SAVED (W)	NONE	17	NONE	15

*SOLID STATE BALLASTS WERE DESIGNED TO HAVE THE SAME LIGHT OUTPUT AS THE COMPARABLE 60 Hz UNITS

Performance speaks louder than words

Each of the solid-state ballasts were designed to provide light outputs equal to their 60-Hz standard counterparts; thus, comparisons of efficiency and efficacy **(Table 2)** attest to the increased performance of solid state over standard ballasts.

The electrical efficiencies of all ballasts are shown to average about 90%. However, the solid-state ballasts actually supply much less power to the lamps to obtain the same level of light output. Not so obvious from **Table 2**, then, is that the solid-state ballast realizes an overall power savings of about 15 to 17W. In terms of efficiency, these figures represent an overall improvement of 17% for the 40W design and 9% for the 75W ballast.

Other advantages are provided by the solid-state design that are more subtle, but worth mentioning. For example, the old 60-Hz standard ballast is heavy (3-1/2 lbs.). Because of the voltage spikes on the leading edge of each positive and negative alternation, the 60-Hz unit also generates an excessive amount of noise.

In contrast to this, the solid-state design is smaller and much lighter (< 2 lbs.). And even though it operates at a much higher frequency, noise proves less of a problem because the resonant LC tank circuit used produces clean sine waves of power to the lamps.

It's not theoretical—it's practical

Each and every component used in the solid-state design is cost effective, readily available and well within the present state-of-the art. In contrast to old inverter ballast designs which used expensive high-frequency coils to limit lamp current, this design employs economical "orange-drop" capacitors.

While they must be wound with Litz wire or an equivalent, the ferrite E cores used for the power transformer are small and inexpensive. The only remaining critical components, the power transistors, are basically lower current versions of popular horizontal-deflection transistors utilized in most TV sets. In response to the recent demand for low-power switching supplies, a great number of these devices are now available on the market.

As noted previously, the voltage requirements of the 75W ballast are beyond the present capability of "orange-drop" capacitors, and more expensive mica units must be used. Because of this situation, present-day "best guess-timates" show a 2:1 cost disadvantage for the 75W design.

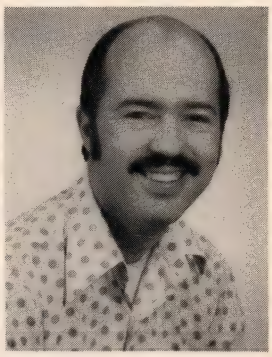
However, standard cost-reduction programs will probably be effective, and these solid-state designs (or similar versions) should appear on the market within two years. In fact, current lab work with a higher power ballast for a 400W metal-halide lamp indicates that these circuits could be cost effective almost immediately.

To date, the circuits built and tested have operated from the 120V line and used 700V transistors. Since standard 1500V transistors are now available, designs working off a 220V line seem feasible.

Unfortunately, the other "standard" voltage for fluorescent circuits is 277V, and supply voltages up to 480V are not unusual. Even though experiments with 3-kV transistors are now fairly common, standard transistors with these voltage requirements will probably not appear on the market in the near future.

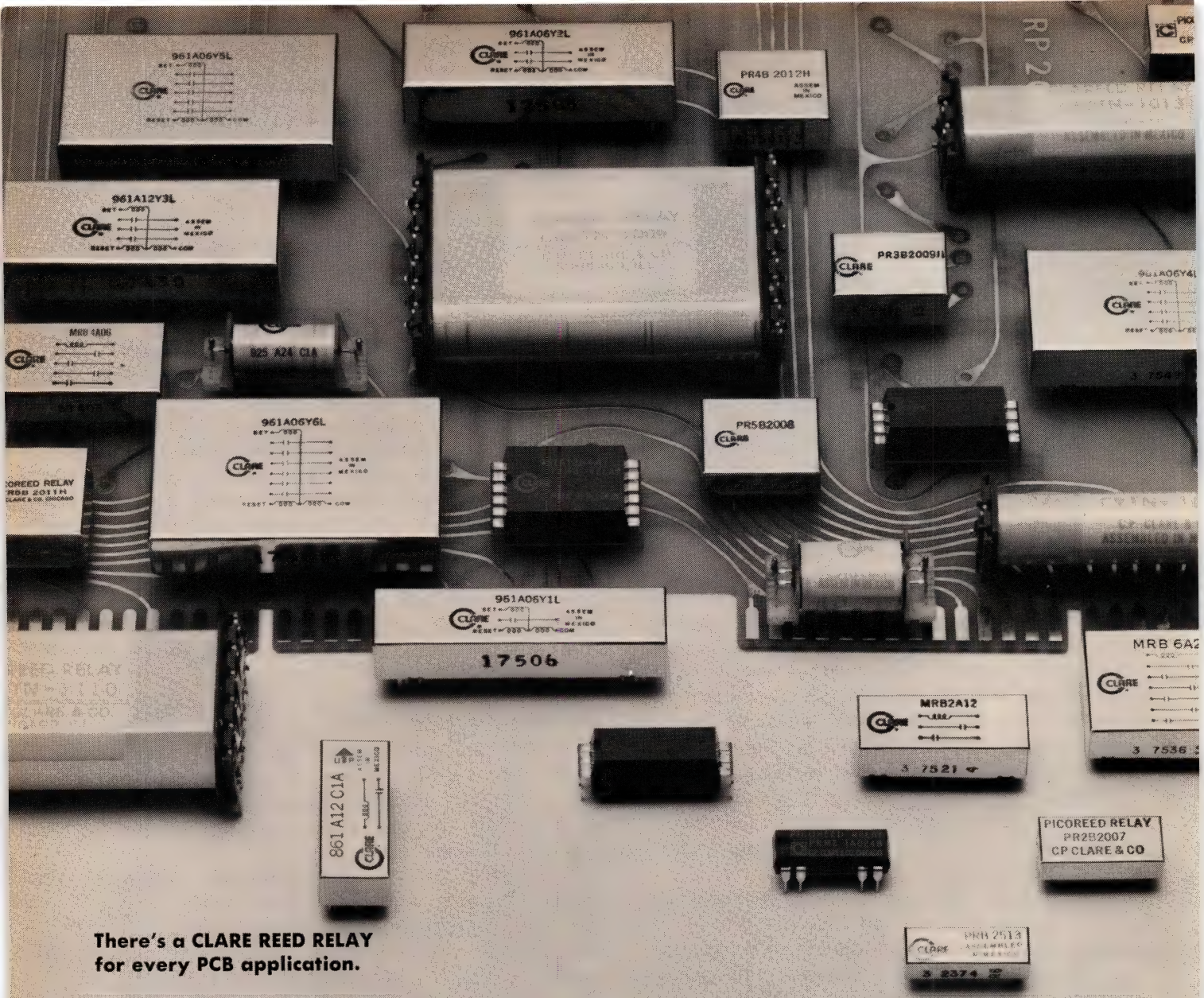
Thus, while direct operation from a 277V line doesn't appear feasible, utilizing a series-switching preregulator can still make the solid-state ballast practical. Using the same filter choke now in the design and one extra power transistor, the preregulator scheme could adapt the 120V design to any higher voltage desired. □

Author's biography



Robert J. Haver is a product applications engineer at the Semiconductor Div. of Motorola, Inc. in Phoenix, AZ. His present responsibilities include product support and customer assistance in the area of power transistors. A graduate of Syracuse Univ. (BSEE), he has been with the company 10 years and holds one patent. Bob, together with his family, enjoys softball and camping when time permits.

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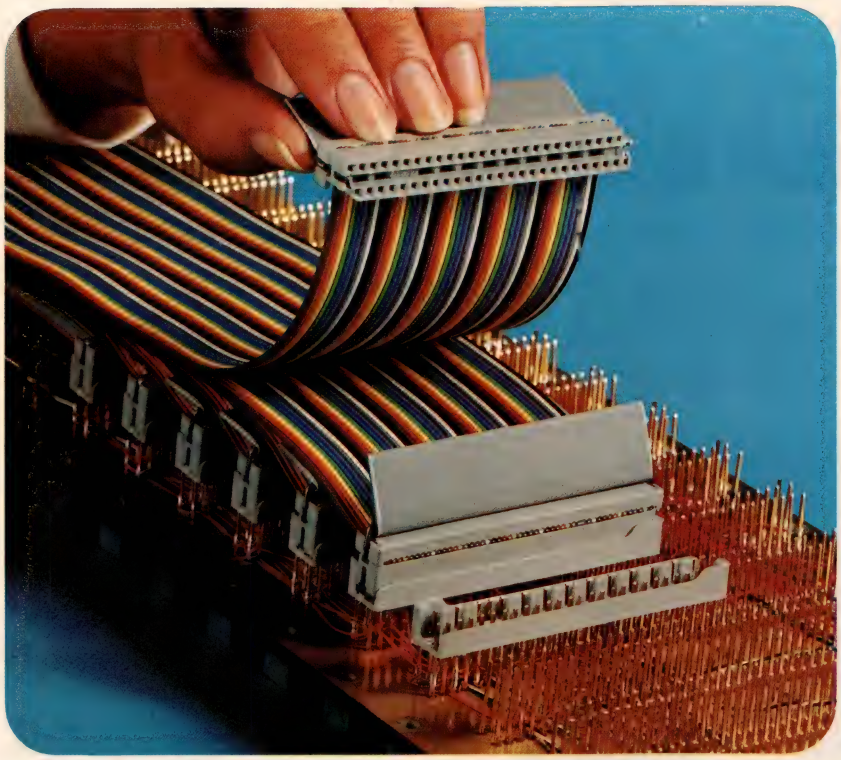
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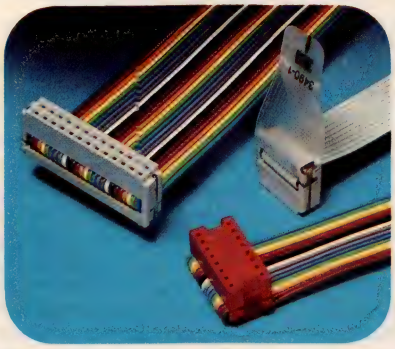
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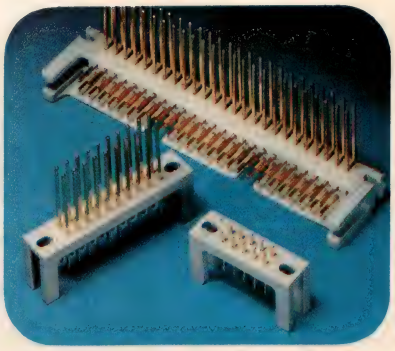
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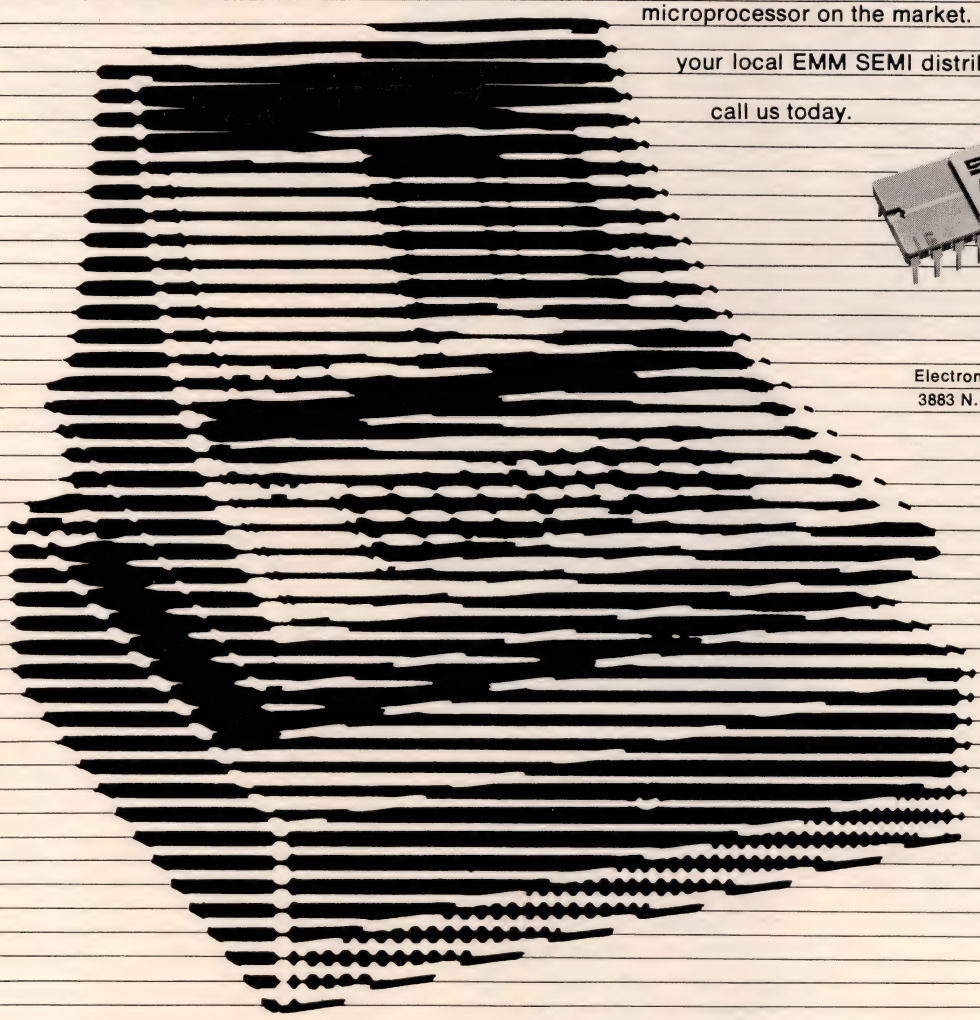
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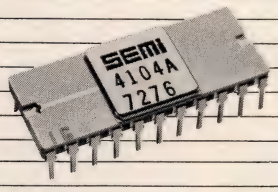
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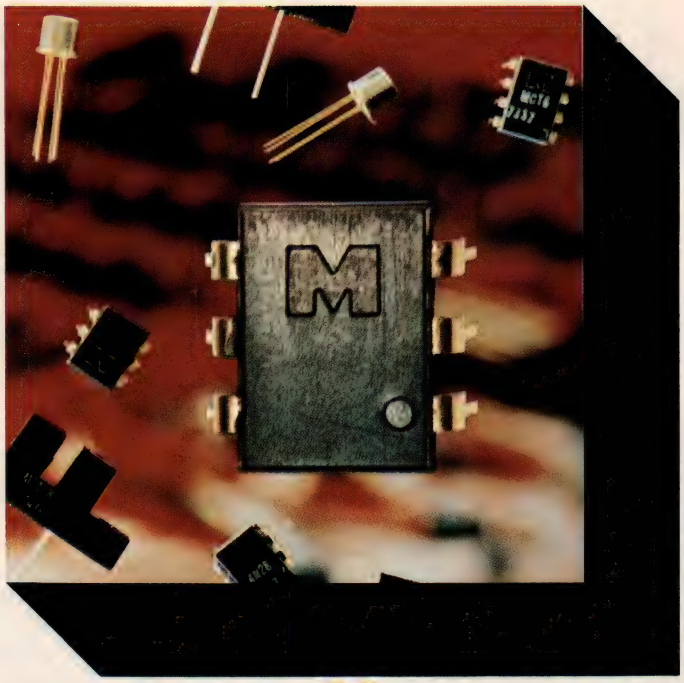
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Logic Gate	8 Lead Plastic DIP	0.1MHz-1.0MHz	2000

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		200μA @ 20mA, 10V
Darlington	Slotted Limit Switch	1.6mA @ 50mA, 1V
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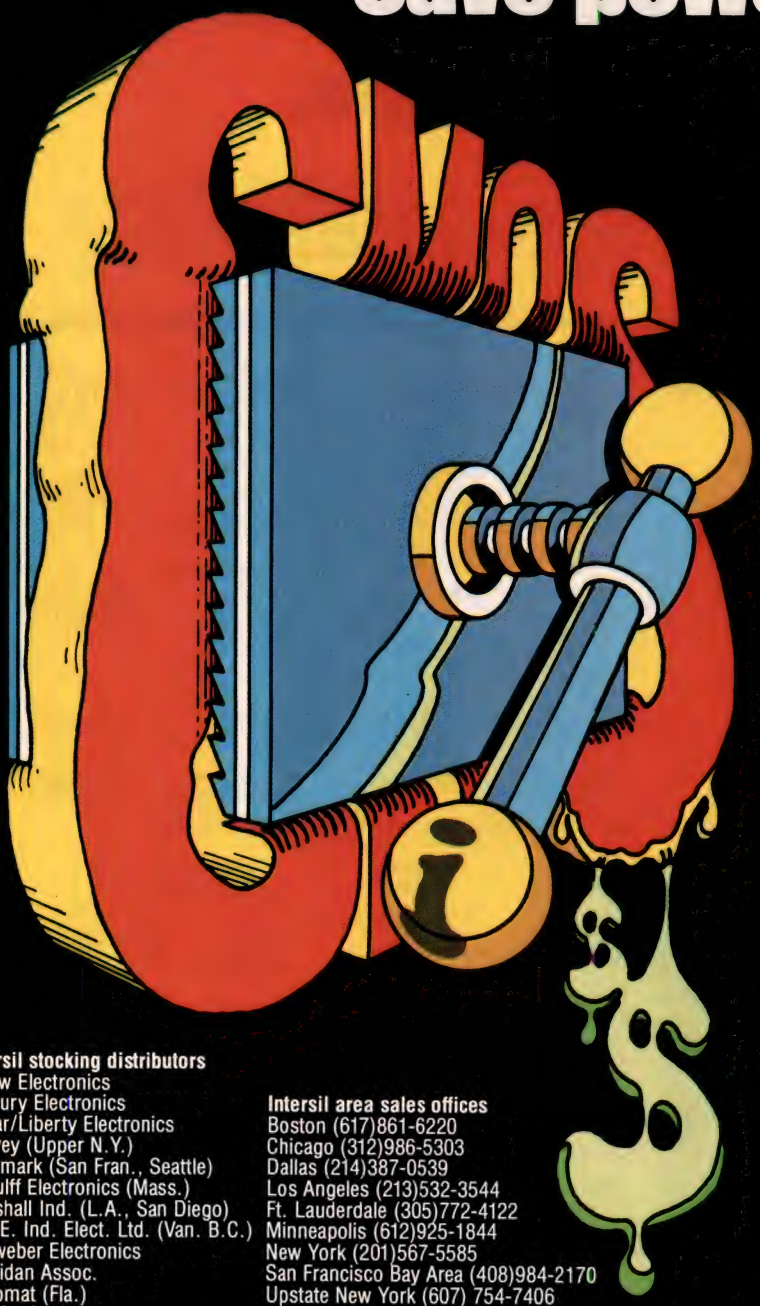
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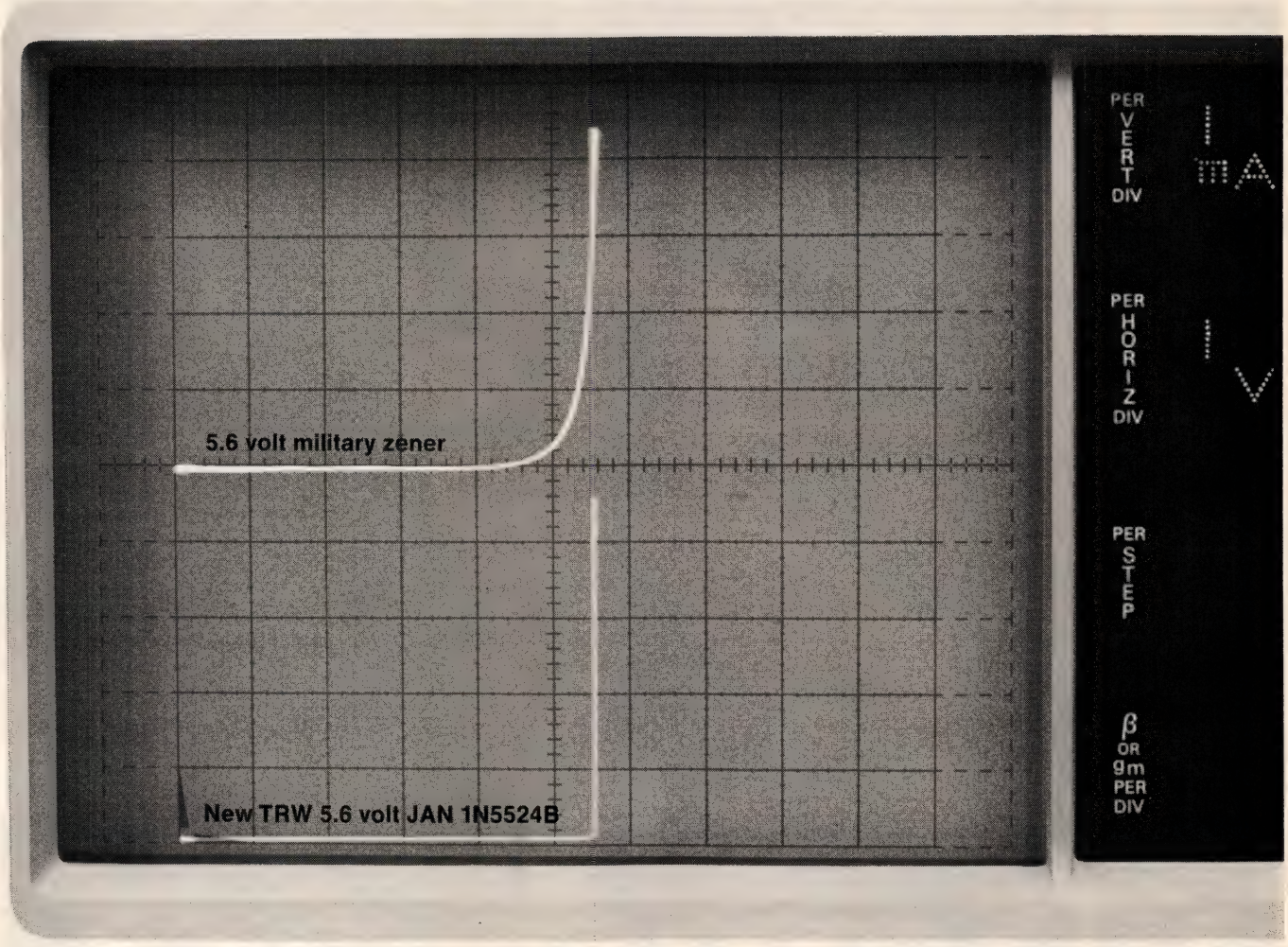
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Presenting: The answers to our quiz on DAS modules

By studying our explanations, you should be well prepared to apply these versatile data-acquisition system building blocks.

ANSWERS

1. c	**6.** d
2. d	**7.** c
3. a	**8.** b
4. c	**9.** a
5. d	**10.** b

We told you the questions weren't easy! If you got less than four correct, we recommend a brush-up on your DAS-module usage. Five to seven correct answers is a job well done, though we advise that you proceed carefully when working with sophisticated applications. But if you scored eight or more questions correctly (an excellent performance!) you should have no difficulty using DAS modules.

In any case, the following explanations to each question should help clear up any confusion or misunderstandings.

1. The high-input impedance of most data-acquisition system modules is deceiving because dynamic considerations exist that limit the maximum usable source impedance to a relatively low value. Every multiplexer has an output capacitance that gets connected to the selected channel, and this capacitance must be charged through the signal-source impedance.

Because the multiplexer, differential amplifier and sample/hold require 4-5 μsec to settle the input signal, the time constant (τ) formed by the source impedance and multiplexer capacitance should be very short (<1 μsec). A time period equal to 9.2τ is required to settle to 0.01% (1/2 LSB for 12 bits). Therefore, assuming the MUX capacitance to be 20 pF, settling time = $(R_{source})(C)(9.2) = (R_{source})(20\times10^{-12})(9.2)$. Thus, a source impedance of 5 kΩ will require a settling time of $(5\times10^{3})(20\times10^{-12})(9.2) = 0.92$ μsec.

Note also that other dynamic limitations further restrict the maximum source impedance for a given throughput; for example, charge PUMP-OUT from the multiplexer back into the source capacitance and resistance.

2. If the differential-amplifier low input is tied to analog ground, the amplifier can no longer differentiate between common voltages on the signal and analog ground. But if the signal-source common or return is tied to the differential-amplifier low, then the amplifier can reject common-mode voltages appearing on the signal inputs.

One drawback exists for the latter approach, however, that holds for all single-ended systems: Because only one switch of the multiplexer is dedicated to each channel, all signal-source commons must be tied together at the differential-amplifier low input.

3. How do we get the 0.488-mV/μsec slew rate? Recall that for a ±10V (20V p-p) input, a 12-bit A/D converter resolves 4.88 mV/LSB. Further, a 100-kHz throughput requires 10 μsec/channel sampled. Therefore, the input cannot change more than 4.88 mV/10 μsec, or 0.488 mV/μsec.

4. The output of the sample/hold amplifier contains an offset error derived from both the pedestal (inherent in most sample/hold's), and from the basic op-amp offsets in the differential amplifier. These offsets in most data-acquisition modules zero-out at the comparator of the A/D converter as a bulk zero, even though they remain in the individual stages.

Inserting a switchable-gain amplifier anywhere in the DAS module (except immediately after the multiplexer which has no offset), will produce errors, when you consider the overall data-acquisition function. Why? Because the offset will be multiplied and therefore appear as different offsets to the A/D at different gains. Thus, a fixed

trim at the comparator would be correct at only one gain setting.

5. The sample/hold control usually ties to the end of the conversion signal. Thus, whenever the A/D converter performs conversion, the sample/hold is in the HOLD mode; and when the A/D isn't converting, the S/H is in the SAMPLE mode.

Almost all modern 12-bit successive-approximation converters use the Type 2504 successive-approximation-resister (SAR) IC. When the A/D triggers, the clock must be gated ON. Because of this, a finite delay exists between the A/D trigger pulse and the moment that the SAR actually causes the END-OF-CONVERSION (EOC) signal to go to busy. This delay could range from 20 to 230 nsec, depending upon how the DAS-module manufacturer implements the clocking.

6. All three alternatives will increase throughput. If the A/D converter is "short-cycled" (operated at lower resolution), it will require less time to make a conversion because the last LSB's need not be tested. Further, if the multiplexer is directed to the next channel while the previous channel's voltage is held in the sample/hold during conversion, that effectively eliminates the MUX's switching and settling time from the next channel's acquisition time. Note, though, that the feedthrough of the sample/hold must be very low, or the process of switching the MUX will introduce errors into the voltage being held for conversion.

7. DAS modules with 12-bit resolution can easily connect directly to an 8-bit μC. To input all 12 bits of the A/D output word requires a 2-word transfer. You can readily accomplish this because of the 3-state outputs. The first input instruction enables bits 5-12 (LSB); the second instruction, the remaining MSB bits.

8. We recommend that you use an interrupt-driven interface. True, the interface would operate with either program or memory-mapped I/O; however, an interrupt-driven interface allows real-time events to control the processor and it also eliminates unnecessary software overhead. Remember that both memory-mapped and program I/O tie up the μC I/O bus for the entire length of time the peripheral is busy, while an interrupt allows the μC to perform other tasks until data is ready.

9. Calculation of the throughput time is as follows:

Load channel and start A/D conversion (one I/O instruction)	= 3 μsec
Data-acquisition system module throughput time	= 10 μsec
Test A/D DONE condition (one I/O instruction, one test instruction)	= 6 μsec
Input 12-bit A/D word (two I/O instructions)	= 6 μsec
Load memory from accumulator (two memory instructions)	= 6 μsec
	Total = 31 μsec

10. The cost of each approach computes as follows:

Four data-acquisition system modules at $175 each	= $700
One data-acquisition module at $175 plus one expander module at $450	= $625

The 64-channel system using one data-acquisition module plus an expander is obviously the lowest cost approach at $625. However, if throughput time is important, the system with four DAS modules can scan all 64 channels in only 25% of the time that the module plus expander would require. Since both approaches only differ by $75, the latter approach may well prove better. □

Authors' biographies



Fred Molinari *(left)* and **Aaron Fishman** co-founded module-maker Data Translation three years ago. As president of the successful Natick, MA firm, Fred manages the company's operations and directs new product concepts. Aaron's responsibility as vice president of engineering is to turn these concepts into realities. Fred received his BSEE from Worcester Polytechnic Institute, his MSEE from Northeastern Univ., and his MBA from Harvard; Aaron, his BSEE from Tufts Univ. In his leisure time Fred enjoys gardening and skiing; Aaron's outside interests include sailing, robins and painting.

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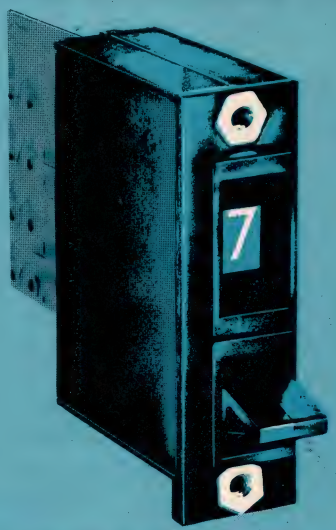
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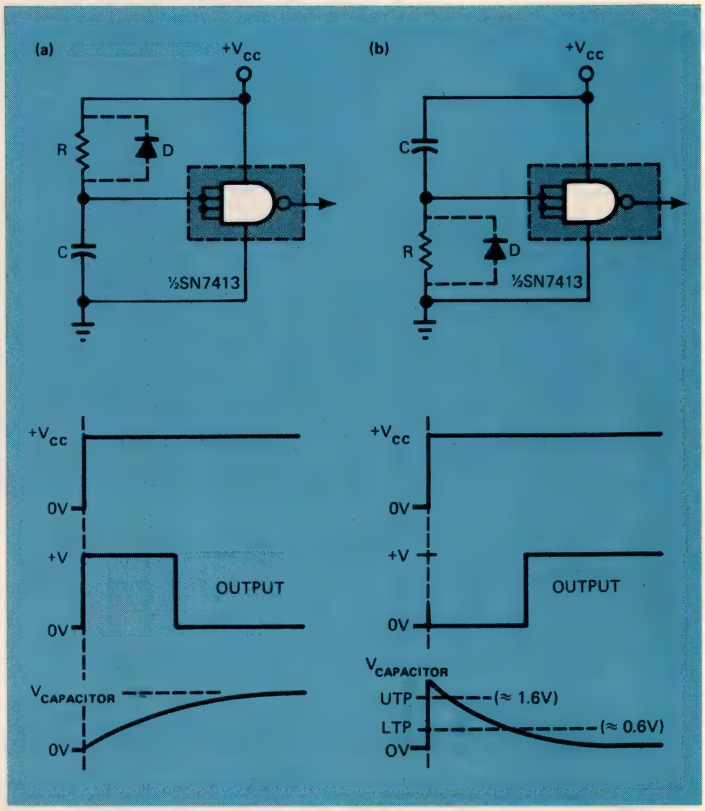
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In circuit **(a)** the uncharged capacitor holds the Schmitt trigger input LOW (and therefore the output HIGH). The application of power charges the capacitor to the upper threshold point of the trigger, causing the output to go LOW. The waveforms in **(a)** illustrate this process.

In **(b)**, since the capacitor is connected between V_{cc} and the trigger's input gate, power-ON immediately fires the trigger, causing the output to go LOW. Then, as the capacitor discharges below the lower threshold point of the trigger, the output goes HIGH. See the waveforms in **(b)**.

The optional 1N914 diode makes the capacitor discharge rapidly during a power interrupt. □

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Bruce E. Patterson
IBM, Boca Raton, FL

Several applications require the use of a combination ramp/pulse generator in which both the frequency and amplitude of the output waveforms show little variation with wide power-supply (V_{cc}) fluctuations. The circuit shown in **(a)** is a modified programmable, unijunction-transistor (PUT) relaxation oscillator to which I've added a source-follower buffer amplifier, a FET current source, the zener diode at the gate of the PUT, and the common-base amplifier at the cathode of the PUT.

The addition of the current source allows a "constant" charging current for the timing capacitor, C_1, and also improves the linearity of the ramp. The gate zener diode, D_2, unaffected by variations of V_{cc}, fixes the amplitude of the output ramp by insuring that the PUT always "fires" at the same voltage level. The interaction of the zener diode and the current source tends to lock the frequency against variation of V_{cc}. Diode D_1 provides temperature compensation.

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$$t = (C_1 \times V_g)/i$$

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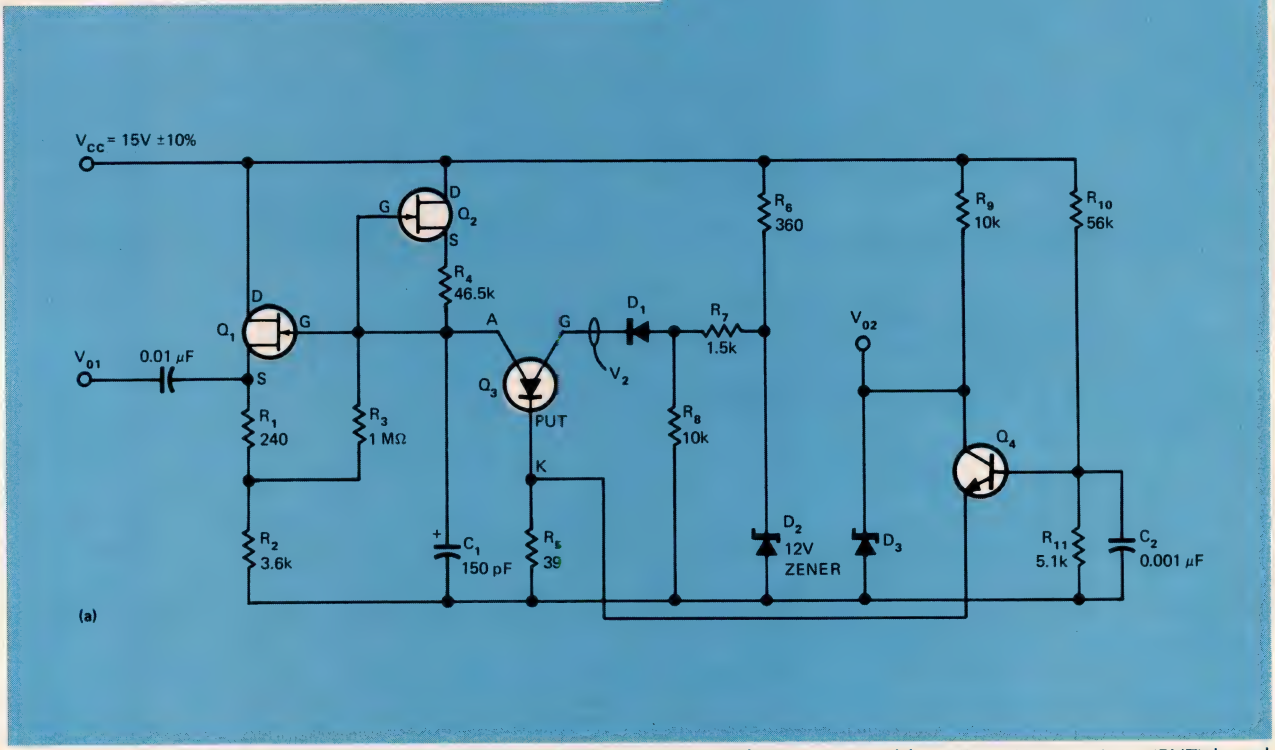
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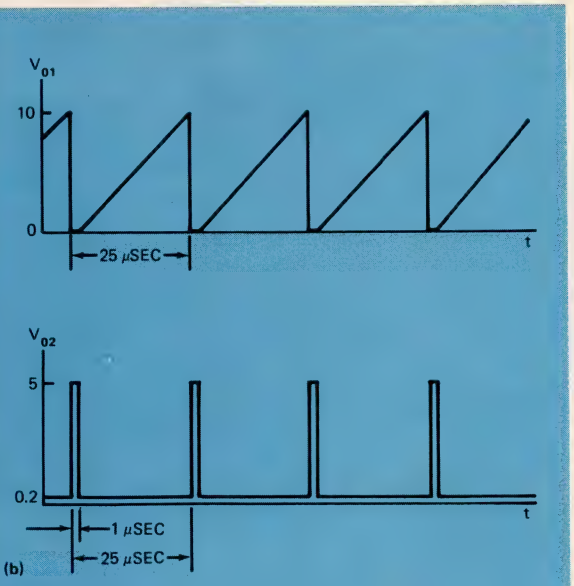
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with 10V amplitude. It was found that a ±10% V_{cc} variation produced only a ±0.65% frequency variation, and had no effect upon the amplitude of the output waveforms (shown in **b).**

When the capacitor, C_1, charges to approximately V_g, the PUT "fires," allowing the capacitor to discharge through R_5. The pulse developed during this operation drives transistor Q_4 from saturation into cutoff. Thus, the pulse output (V_{02}) goes from a normal level of V_{ce} (saturated) to a value determined by zener diode D_3. Upon complete discharge of C_1, the PUT turns off and the cycle repeats. □

To Vote For This Circuit
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V_{cc} fluctuation can kill a circuit requiring a stable ramp/pulse generator. This programmable unijunction transistor (PUT)-based circuit shows only a ±0.65% variation in frequency, with no loss of amplitude for a ±10% supply deviation.

Data collector selectively multiplexes inputs

Joe H. Apple
EG&G, Rockville, MD

If you need a data-collection circuit capable of selectively multiplexing different numbers of inputs on sequential scans, this design might provide the solution.

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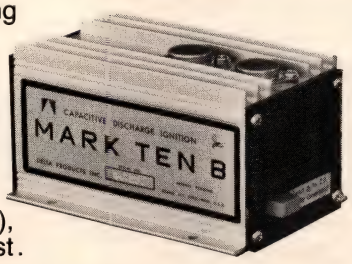
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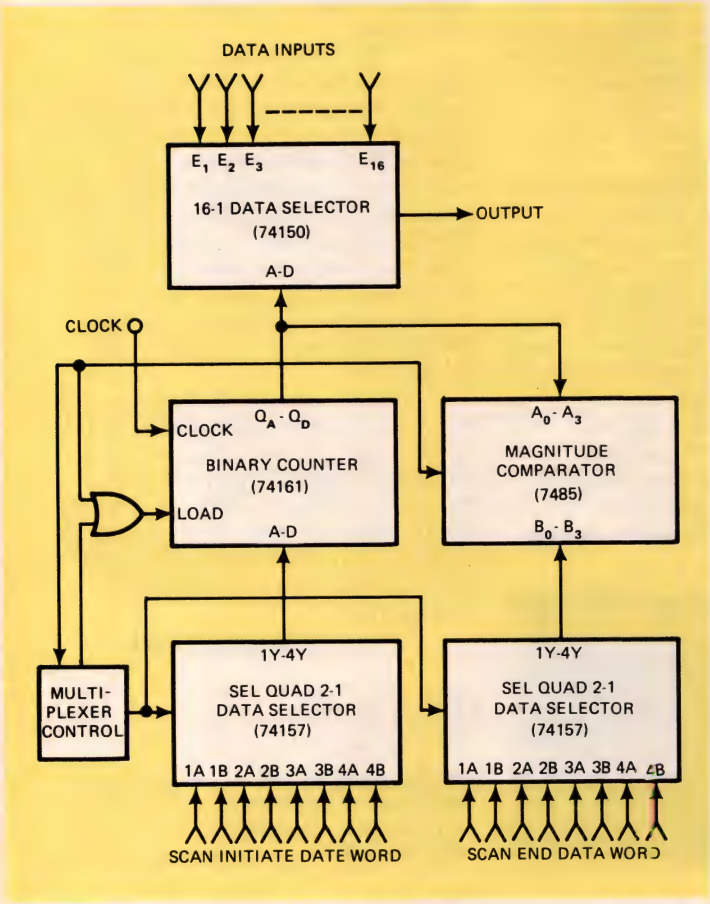
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Versatile variable-length multiplexer can selectively MUX differing numbers of inputs or sequential scans.

binary representation of scan-initiate data word, "2," is applied to the parallel load inputs of the counter through the quad 2-1 data selector. Also during the first scan, the binary representation of scan-end data word, "8," is applied to the magnitude comparator through the quad 2-1 data selector. Upon command of the multiplexer-control circuit, the scan-initiate data word loads into the counter and the counter enables. The multiplexer immediately samples input "2," continuing at the clock rate until it reaches a count of 8. At this time, the magnitude comparator indicates that the counter has reached the scan-end data word and the multiplexer-control logic stops the scan. By presenting different scan-initiate and scan-end data words (by switching the quad 2-1 multiplexers), scan patterns can be generated.

You can expand this variable scan-length multiplexer to include longer numbers of inputs by increasing the number of 16-1 line multiplexers and selectively enabling the appropriate multiplexer chip. Finally, the scan lengths and starting and end points can be varied in greater detail by employing 4-1 data selectors in place of the 2-1 data selectors. □

To Vote For This Circuit
Circle No. 323

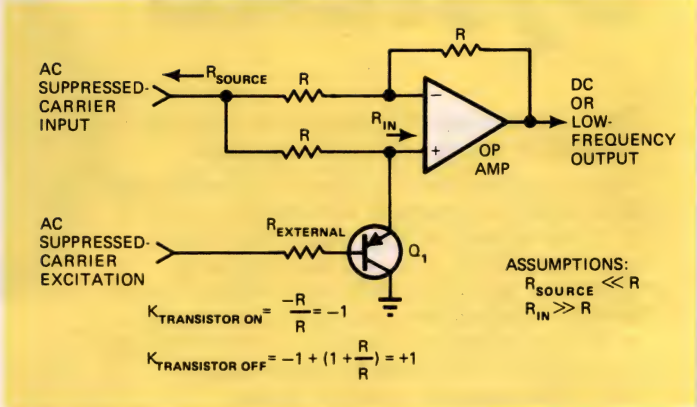
Suppressed-carrier demodulator uses two active devices

C. E. Musser
General Electric, Binghamton, NY

In ac suppressed-carrier servo systems, command or signal information is extracted from the carrier through a demodulator circuit. The demodulator circuit illustrated here has good accuracy, is simple to mechanize, and has a straightforward theory of operation.

When the transistor switch is ON, the op-amp gain equals −1. When OFF, the op-amp gain becomes −1+2 = +1. Thus, the circuit provides a unity-gain function constant with alternating polarities and will deliver bipolar outputs depending on the phasing of the signal relative to excitation.

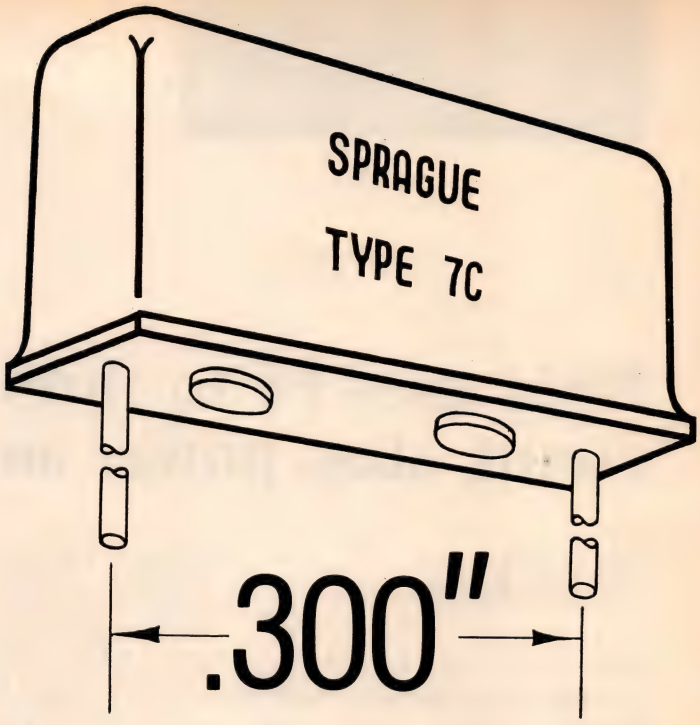
This circuit has been used with a 741 op amp and a 2N2945 pnp transistor switch. Metal-film resistors of ±1% were also implemented. For accuracy considerations, R_{source} must be much smaller than R and preferably from the output of another closed-loop op amp. R_{in} should also be much larger than R to avoid gain loss in the noninverting path. □



A single op amp and transistor switch do an ac, suppressed-carrier demodulator make! The circuit provides unity-gain constant with alternating polarities.

To Vote For This Circuit
Circle No. 324





COMPATIBILITY

SPRAGUE GIVES YOU A CHOICE OF 2 MONOLYTHIC® CERAMIC CAPACITORS THAT GO HAND IN HAND WITH ALL TYPES OF STANDARD DIP COMPONENTS

Type 933C DIP-Style* Molded-Case

Moisture-proof case offers excellent mechanical protection during hand or automatic insertion. Made by alternately depositing thin layers of metallic electrodes and ceramic dielectric until desired capacitance is obtained, then firing into a homogenous block. Capacitance range: 18 pF to .1 μF @ 100 WVDC; to .22 μF @ 50V; to .47 μF @ 25V.

Type 7C Saddle-Base Resin-Coated

Tough resin case, with outer epoxy varnish coating, protects against damage from handling as well as moisture. Phenolic base plate insures accurate lead spacing and eliminates resin run-down on leads. Capacitor sections made with proven layer-built construction. Capacitance range: 51 pF to 1 μF. Voltage ratings: 50 and 100 WVDC.

For more information on these and other Monolythic® Ceramic Capacitors, write for Short-Form Catalog MC-108 to: Technical Literature Service, Sprague Electric Company, 491 Marshall Street, North Adams, Mass. 01247

4SZ-6119

SPRAGUE®
THE MARK OF RELIABILITY

Sprague puts more component families into dual in-line packages than any other manufacturer.

For more information, Circle No. 50

DPM uses I^2L to shrink parts count, size, power and cost

PROGRESS IN COMPONENTS

Smaller and more accurate than its analog counterparts, Analog Devices' AD2026 digital panel meter enters a price range competitive with high-quality APM's. Specifically, this 3-digit, logic-powered device with large 1/2-in. LED's costs just $39 in 100-piece quantities.

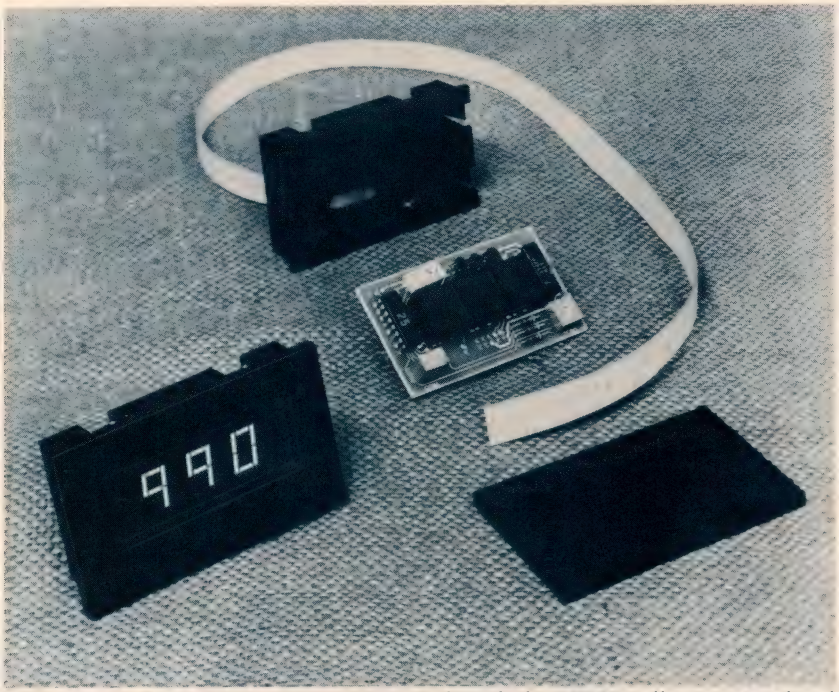
Competing with APM's

Since its case measures only 3.4×2.0×0.85 in., the AD2026 occupies less space on and behind its mounting surface than APM's with 3-1/2-in. scale lengths. Yet this DPM provides readout resolution and repeatability superior to 4-1/2-in. meters: While most APM's offer accuracy near 2%, the digital unit boasts 0.1% of reading ±1 digit.

Because APM manufacturers have long praised the high reliability of their products, many users are wary of converting to DPM's. The AD2026, though, eliminates two major problem areas: internal heating and large component count. The meter draws only a low 0.75W max. from a single +5V supply, and contains only 14 electrical components, half of them passive. Results from multiple tests support the theoretical MTBF of 260,000 hours at +25°C.

The converter incorporated in the 2026's I^2L chip uses a dual-slope integrating A/D technique to provide four conversions/sec. At the input, a balanced differential circuit can tolerate a sustained overvoltage of ±15V dc, and can handle 200-mV common-mode voltages (CMR is 50 dB). Simple logic circuitry offsets input-voltage values, permitting a 10% negative capability and allowing a measurement range from −99 to +999 mV.

Unlike APM readouts, the AD2026 can display values in various engineering units, with scale factors determined by a simple resistor network. And because the display blanks during conversion, it does not interact with the converter, affording outstanding differential linearity.



With circuitry complete on a single snap-in board, the AD2026 offers a streamlined package and a clean front-panel lens. The latter permits the user to individualize the DPM with his own logo, measurement information, or customized styling.

A neat package

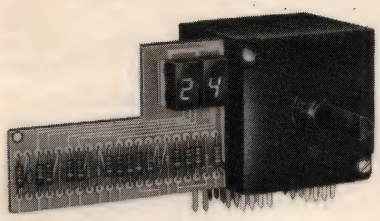
The AD2026 also offers simplicity of installation. Its snap-in case (patent applied for) requires no tools or hardware for assembly or mounting.

All AD2026's undergo extensive factory QC testing, including a 168-hr burn in. Delivery is from stock.

Analog Devices, Inc., Box 280, Norwood, MA 02026. Phone (617) 329-4700.

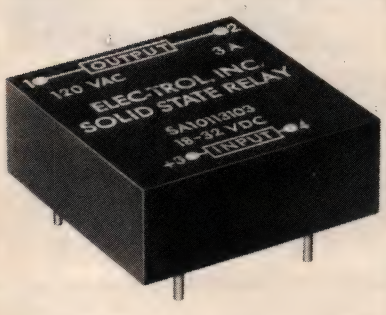
Circle No. 297

COMPONENTS/PACKAGING



SWITCH. "Rotocode" is a combination thumbwheel/rotary switch. In the basic version, a rotary shaft drives 1 or more pc discs whose concentric traces rotate past stationary wipers. Max. bit count (each side) is 7 plus common. Even in the simplest form, 1 disc replaces a multideck rotary switch. In the expanded version, a customer-specified pc board is added ahead of the first disc and rotating wipers act on it in thumbwheel fashion. Basic 2-deck unit, $10. **Cherry Electrical Products Corp.,** 3600 Sunset Ave., Waukegan, IL 60085. Phone (312) 689-7702. **Circle No. 232**

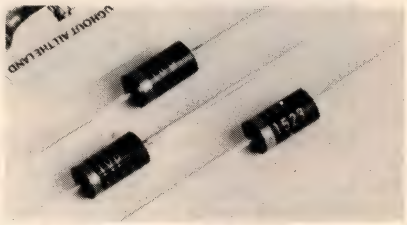
BRIDGE RECTIFIERS. Units in the Series PK-F are designed for 12A operation and join existing 6, 8 and 10A designs. All are available for 50, 100, 200, 400, 600, 800 and 1000V peak reverse operation. Surge-current and dielectric-strength ratings are 150A and 1500V, respectively. Measuring <1 in. in dia., the devices can be chassis or heat-sink mounted and accommodate 1/4-in. quick-disconnect terminations. $1.50 (1000) for a 400V model. **Electronic Devices, Inc.,** 21 Gray Oaks Ave., Yonkers, NY 10710. Phone (914) 965-4400. **Circle No. 233**



S.S. RELAYS. Designed for direct pc-board mounting, these measure only 1.27 in.^{2}. They can switch up to 3A at 120 or 240V ac, and come with input ranges of 3 to 8, 8 to 18 and 18 to 32V dc. Capable of being directly driven by TTL logic, the relays feature zero-crossover switching, input/output photo isolation, epoxy encapsulation, IC compatibility, long life and immunity to shock and vibration. $5 (1000) for a 1.5A, 120V model. **Elec-Trol, Inc.,** 26477 N. Golden Valley Rd., Saugus, CA 91350. Phone (213) 788-7292. **Circle No. 234**

PC CONNECTORS. A line of 2-piece microminiature metal-to-metal units, the 8300-Series connectors use miniature Varicon™ contacts that are mutually embracing, hermaphroditic, spring loaded and interlocking. Standard units are available with up to 20 positions. The contacts (phosphor bronze with gold-over-nickel plating) are rated for 3A and have contact resistance of 6 mΩ. Approx. 10¢/contact, with delivery 8 wks. ARO. **Elco Corp.,** 2250 Park Pl., El Segundo, CA 90245. Phone (213) 675-3311. **Circle No. 235**

POT. The 112-P19 is a high reliability, low cost, conductive-plastic potentiometer. Resistance values range from 500Ω to 100 kΩ with standard linearity of ±0.5%. The unit features a solid-molded raised track, unique high-pressure wiper assembly and superior wiper-contact material to obtain a life of 10^8 revolutions. Gold-plated terminals, beryllium-copper wiper spring and stainless-steel shaft and ball bearings come standard. $21 (100). **Maurey Instrument Corp.,** 4555 W. 60th St., Chicago, IL 60629. Phone (312) 581-4555. **Circle No. 236**



SUPPRESSORS. A line of zener-type devices, the TVP1500 Series features 1500W peak pulse power (1.5J), a voltage breakdown range of 8.2 to 2000V and recovery time of approx. 1 nsec. Packaged in polymer silicone cases that withstand 400°C temp., the line has a reverse standoff range of 6.6 to 171V and operates over the temp. span of −65 to +175°C. $1.35, with delivery 6 to 8 wks. ARO. **TRW Capacitors,** 301 W. O St., Ogallala, NB 69153. Phone (308) 284-3611. **Circle No. 237**

Switch Access From Racked PC Boards



Grayhill Piano-DIP™ Side-Actuated Rocker DIP Switches

SPST circuitry under each rocker... Dimensionally compatible with SPST, SPDT, and DPDT Rocker DIP switches and standard sockets.

- **Positive identification of rocker position from the side of the mounted switch.**
- **Low profile...can be readily edge mounted on racked PC boards.**
- **Grayhill's reliable spring loaded, sliding ball contact system...life rated at 50,000 operations with positive wiping action and immunity to normal shock and vibration.**

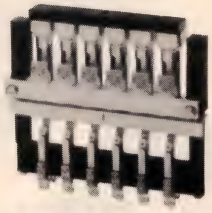
Here's the latest entry to the comprehensive and innovative Grayhill DIP switch line...a new switch that can be actuated without removing the PC board from its rack. Because of its distinctive shape and side actuation, Grayhill calls this the PIANO-DIP™. It's ideal for mounting on the exposed edge of a racked PC board, allowing engineer or technician easy programming access. PIANO-DIP™ switches are now offered with 7 rockers; future versions will include 4 to 10 switch stations. Complete information is contained in Bulletin 260R321, available free on request from Grayhill, Inc., 561 Hillgrove Avenue, La Grange, Illinois 60525; phone: (312) 354-1040.

Grayhill INC

For more information, Circle No. 51

an investment in capitol buys rugged switch design and long, trouble-free life

For Example!
Our Extremely Dependable, Multiple-Position Push Button Strip Switches



Basic frames are anodized aluminum. Plungers are 5/32" square brass with a nylon actuator molded on them. Hence, they will not bend or warp.

Mechanical linking of all switch positions prevents operation of more than one position at a time. A released button will return to the "up" position before the next button can be actuated. These switches can be illuminated either by an external circuit or directly from the switch. Lamps do not travel when positions are engaged, eliminating shock to the bulb.

Capitol switches are tested with 2 to 3 million operations to assure life-long, trouble-free performance.



Our 28-page catalog will give you all the "specs" on CAPITOL's entire line of quality switches.

CAPITOL manufactures a complete, high-quality line of push button and lever switches — illuminated if desired — standard and custom designs to fit your every need.

CAPITOL

The Capitol Machine and SwitchCo.
87 Newtown Road, Danbury, Conn. 06810
Phone: 203-744-3300

For more information, Circle No. 52

COMPONENTS/PACKAGING

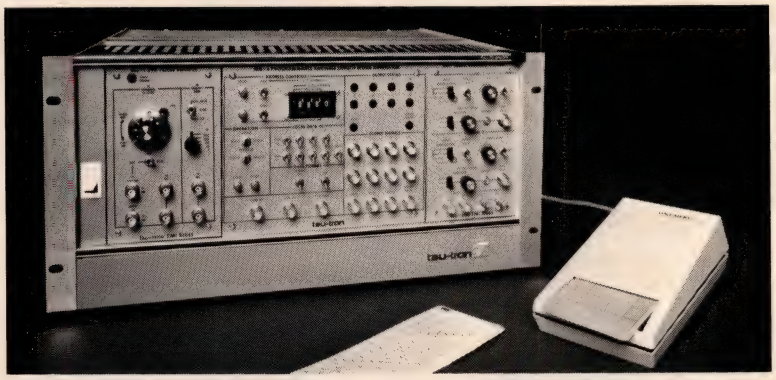


VARIABLE ATTENUATORS. Models 940-60-1 and 940-114-1 offer continuously variable attenuation from 0 to 60 dB (dc to 4 GHz) and 0 to 114 dB (0 to 2 GHz), respectively. Both models handle 5W average (500W peak) power and have a 50,000-cycle rated life. Insertion loss is 6 dB min., while max. VSWR is 1.5 at 1 GHz and 1.8 at 4 GHz. Dial accuracies for the -60-1 and -114-1 are ±0.5 dB or 1% at 2 and 1 GHz, respectively. $460 for -60-1; $555 for -114-1. **Weinschel Engineering Co.,** Gaithersburg, MD 20760. Phone (301) 948-3434. **Circle No. 238**

SWITCHES. In addition to offering double-throw action in a miniature case, the MPN Series snap-action push buttons provide isolated connection to the lamp for increased flexibility. Standard T-1-3/4 grooved-base lamps are easily removed from the front without special tools. Contacts and terminals are gold-flashed for extended life (50,000 operations min.) and oxidation inhibition. Contacts carry ratings of 6A at 125V ac, 3A at 250V ac. $2.65 (1000). **Alco Electronic Products, Inc.,** 1551 Osgood St., N. Andover, MA 01845. Phone (617) 685-4371. **Circle No. 239**

TIME-DELAY RELAY. A versatile device, the Model 336 operate-delay relay comes in 84 different time/voltage configurations and with 7 coil voltages ranging from 12 to 230V ac or dc. Standard time delays (12) run from 6 min. to 24 hrs. Contacts are heavy-duty dpdt types rated for 10A. All circuitry is transient-protected for 2500V, and repeat accuracy runs well under 1%. Approx. $40, depending on qty. **Time Mark Corp.,** Box 15127, Tulsa, OK 74112. Phone (918) 939-5811. **Circle No. 240**

New...Words and Bits to 50 MHz



MG-3 variable length, programmable data/word generator

If you need 8 bit parallel words up to 128 words (256 with the optional memory expansion) . . . or a serial word selectable in bit increments from 1 to 1,024 bits (2,048 option) — then our modular MG-3 will do your job.

An auxiliary ninth channel can be used as parity or variable position sync . . . it also has NRZ/RZ control, single cycle mode and remote control.

Load the generator's high speed memory using front panel controls or with the optical card reader shown. You program and change the cards with a pencil.

Apply the MG-3 to testing IC's, digital circuits, and communications components or systems.

Call or write for data sheets and demo.

tau-tron inc

11 Esquire Road, North Billerica, Mass. 01862 Tel: (617) 667-3874

For more information, Circle No. 53

ARROW MPU APPLICATIONS NOTE

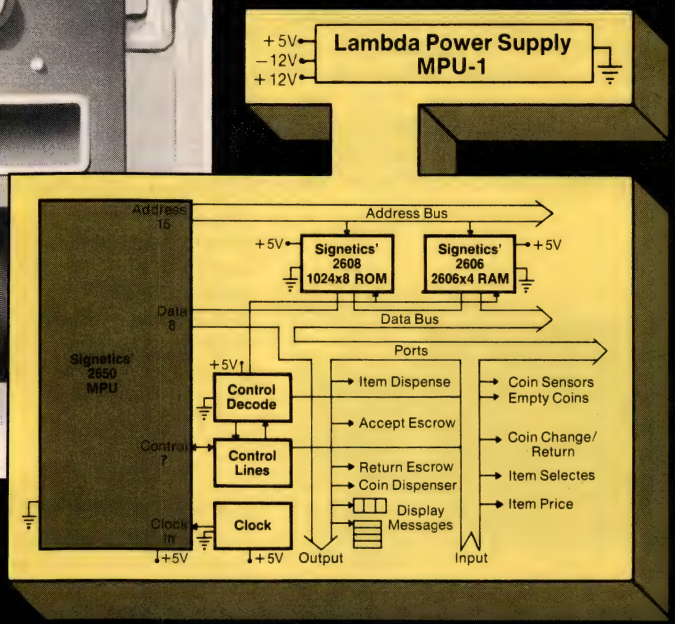
Signetics' 2650 is a vending machine.



Signetics' 2650 8-bit, T²L compatible MPU can be used as an intelligent controller for a vending machine selling such items as books, magazines or toiletries. This control system performs a wide variety of functions. Among other things, it receives inputs which sense the denominations of the coins deposited, and checks that the proper amount has been received for the item desired. It also sends outputs to displays and solenoids to perform tasks such as indicating to the buyer which items are sold out, whether exact change is needed, or if enough money has been put in for the item desired.

The Signetics' 2650 MPU can be used to solve a wide variety of problems in many different areas, such as: security systems, chemical control processes, medical and meteorological equipment.

Use this versatile MPU and related components to solve your next design problem. If we can help, call us. Because at Arrow, we don't just sell and stock components, we also sell ideas.



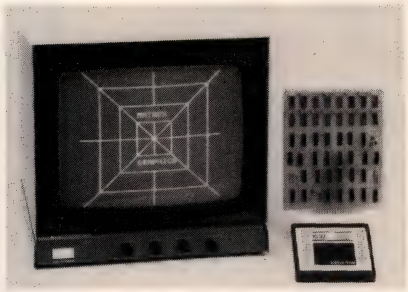
Arrow Farmingdale, New York (516) 694-6800 (212) 995-2100 Dayton, Ohio (513) 253-9176 Cleveland, Ohio (216) 464-2000 Moorestown, N.J. (609) 235-1900 (215) 928-1800 Baltimore, Md. (301) 247-5200 (202) 737-1700 Saddlebrook, N.J. (201) 797-5800 Poughkeepsie, N.Y. (914) 896-7530 Hamden, Conn. (203) 248-3801 Woburn, Mass. (617) 933-8130 Ft. Lauderdale, Fla. (315) 776-7790 Other locations at: Bloomington, Minn. (612) 888-5522 New Berlin, Wis. (414) 782-2801 International (516) 643-4500 TWX: 510-227-8390

For more information, Circle No. 54



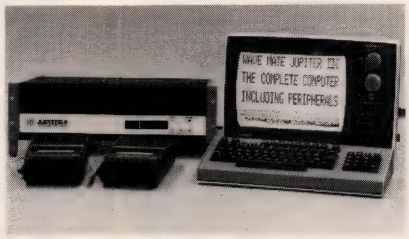
MINICOMPUTER. Supporting a full line of data storage/communications peripherals, the ECLIPSE® C/330 has main-memory expansion capacity to 512k bytes in 64-byte semiconductor, or 32k-byte core, single-board memory increments. Commercial data-processing software includes Fortran, ANSI-74 Cobal, RPG II, RJE/HASP, and INFOS—a data-base oriented file-management system. $58,000 and up (memory and peripheral dependent). **Data General,** Rte. 9, Southboro, MA 01772. Phone (617) 485-9100.
Circle No. 166

SC/MP μP. Preassembled and fully tested, these "SC-8 BOARDS" include all the firmware and components needed to evaluate the SC/MP system. The board, measuring 4×5 in., incorporates a standard 72-pin edge connector. Each unit contains 1 4k ROM preprogrammed with KITBUG, 2 1k RAM's organized into 256 4-bit words, 1 7V regulator, 1 8-bit data buffer, a 1-MHz crystal and a 20-mA current-loop TTY interface. $125 (1-10). **National Semiconductor,** 2900 Semiconductor Dr., Santa Clara, CA 95051. Phone (408) 737-5000. **Circle No. 167**



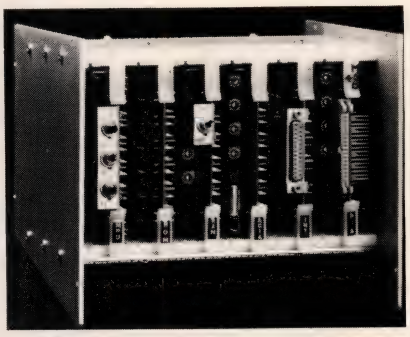
μC GRAPHICS GENERATOR. The MTX-256**2 displays a total of 65,536 dots arranged in a 256×256 dot raster, with each dot individually addressable in <3.4 μsec. The system consists of a central timing-unit module (for interfacing μP timing to TV sync) and a 65k-bit image memory module. To a μP, the unit looks like a WOM with 4 8-bit locations. Locations with addresses 1 and 2 are dot coordinates while addresses 0 and 3 control intensity and/or color resolution. $598. **Matrox Electronic Systems,** Box 56, Ahuntsic Stn., Montreal, Quebec H3L2S0. Phone (514) 481-6838.
Circle No. 168

PROGRAM LIBRARY. Hundreds of 8080 μC programs are now available from the Insite™ software exchange. For a $100 annual fee (waived if you submit an acceptable program), members receive a Program Library Manual with program listings up to 3 pages long, update packages, and 5 free source tapes of their choice. Extra paper tapes cost $15 each. Key programs include disc and paper-tape versions of BASIC. **Intel Corp.,** 3065 Bowers Ave., Santa Clara, CA 95051. Phone (408) 246-7501.
Circle No. 169



MICROCOMPUTER. Jupiter IIC hardware combines a MC6800-based CPU, 8k of RAM, and 3k of ROM with a video-terminal interface, keyboard and dual audio-cassette interface. Software includes a monitor/debugger package with interrupt handling and I/O monitor call instructions. A programmable macro-editor, expanded assembler and proposed ANSI-standard BASIC come standard. $2200 (kit); $3200 (assembled). Both include 2 cassette units and a 12-in. B&W TV. **Wave Mate,** 1015 W. 190th St., Gardena, CA 90248. Phone (213) 329-8941. **Circle No. 170**

FORTRAN COMPILER for MOS Technology/Synertek 6500 μC's lets users program with statements such as COMMON, DATA, DIMENSION, EQUIVALENCE, FUNCTION and SUBROUTINE via time sharing. For flow of control, the language has arithmetic IF, logical IF, DO, GOTO, STOP, PAUSE, RETURN and END statements. Operators include: +, −, *, /, **, // (modulo), .AND, .OR, .NOT, <, ≤, =, >, ≥, ≠ and !! (concatenation). **Remote Computing Corp.,** 1 Wilshire Blvd., Suite 1400, Los Angeles, CA 90017. Phone (213) 629-2532.
Circle No. 171

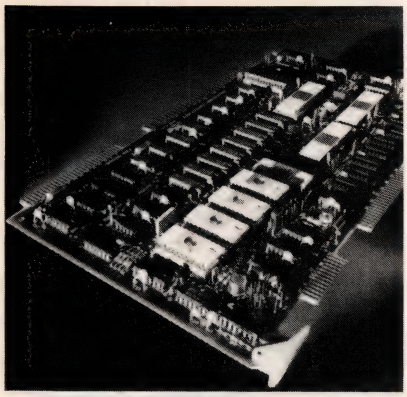


μP CARDS. Based on 6800-family logic, these 4-1/2-in. square Wire-Wrapped® boards come in CPU, PROM, static RAM, ACIA, RS-232 and PIA functions. The CPU treats each function as a memory location with its address selected by hex switches. Since all cards come fully buffered, any number from 3 to 120 can be used per system. A programming card permits writing programs in Model 2704 or 2708 PROM's. $90-$400. **Cambridge Thermionic Corp.,** 445 Concord Ave., Cambridge, MA 02138. Phone (617) 491-5400. **Circle No. 172**

μP LANGUAGE. MicroFORTH™, a multi-level μP language said to reduce execution time by as much as a factor of 10, can also reduce memory requirement from 2k bytes coded in assembler to 1k or less. The standard package includes a compact disc-operating system, macro-assembler, FORTH™ compiler and interpreters, a text editor and interactive debugging aids. $1000. **FORTH, Inc.,** 815 Manhattan Ave., Manhattan Beach, CA 90266. Phone (213) 372-8493.
Circle No. 173

MICROCOMPUTER. Constructed around the Z-80 μP, the Quay 80AI contains all the components necessary to build a stand-alone or ALTAIR- or IMSAI-compatible μC. The system features a 2.5-MHz clock (ϕ1, ϕ2 and sync), ROM-based monitor, RS-232C or 20-mA serial I/O port (at rates to 2400 baud), 8-bit parallel ASCII-keyboard interface port, and PROM programmer. $450 (kit); $600 (assembled). **Quay Corp.,** Box 386, Freehold, NJ 07728. Phone (201) 681-8700. **Circle No. 174**

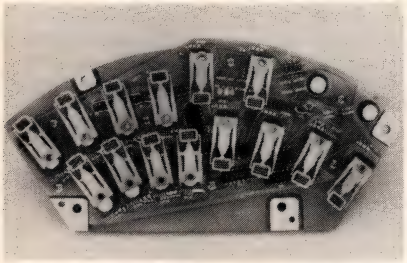
COMPUTERS/PERIPHERALS



SOFTWARE DEVELOPMENT system, the RDP2, makes it possible for Intel SBC 80/10 μC-board users to develop application software with greater efficiency. The package combines an editor, assembler, and monitor (preprogrammed on 4 PROM's) onto a single plug-compatible card for debugging, tape dumping and loading, storage/register modification and program execution. $995, including complete documentation, periodic software updates, and warranty. **Extensys Corp.,** 592 Weddel Dr., Suite 3, Sunnyvale, CA 94086. Phone (408) 734-1525.

Circle No. 175

COMPUTER CARPET. Claimed to be the only carpet guaranteed to meet IBM recommendations for electrical resistance in floor-covering materials, COMPU-CARPET™ employs conductive Zefran® nylon-filament yarn with STATEX-II conductive jute backing. Static potential is reduced below 2000V for ordinary footwear and below 10V for conductive footwear. The carpets carry a 5-year anti-shock warranty. **United Technical Products,** 621 Main St., Waltham, MA 02154. Phone (617) 235-4449. **Circle No. 176**



DISC HEADS. Designed for use by disc manufacturers who utilize Winchester-type data transducers as part of a fixed or hybrid head system, the FH140-Series monolithic R/W flying-head assembly functions on both oxide and nickel-cobalt discs. Versions are available with either 3-track (FH143) or 5-track (FH145) gimbal subassemblies for a total of 42 or 70 tracks, respectively. FH143, $600. Delivery, 90-120 days. **National Micronetics,** 5600 Kearny Mesa Rd., San Diego, CA 92111. Phone (714) 279-7500.

Circle No. 177

DATA TERMINAL. Model 5000 buffered tape-cassette terminal, built around the 250B tape-cassette transport system, is said to be the only system that utilizes a μC for control and efficiency. Programmed high-speed search and powerful edit functions, as well as full communications capability, all come standard. Tape speeds are up to 120 ips on cassettes capable of holding 175,000 characters. The system weighs <12 lbs. **MFE Corp.,** Keewaydin Dr., Salem, NH 03079. Phone (603) 893-1921.

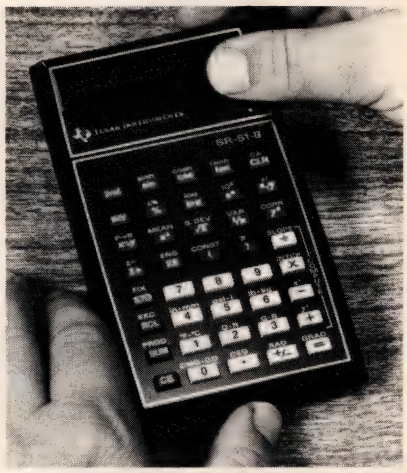
Circle No. 178



MAG-TAPE SYSTEM. CO-30000LSI LINC Tape is said to be the first mag-tape system for the LSI-11®/PDP®-11/03, is 100% DECtape® compatible and offers media interchangeability with any computer equipped with DECtape. Having a capacity of 148k 16-bit words in blocks of 256, the system offers the LSI-11 user a direct-access storage unit. The controller will support a total of 4 drives. First drive and controller, $1995; portable model, $2295. **Computer Operations, Inc.,** 9700-B George Palmer Hwy., Lanham, MD 20801. Phone (301) 459-2100.

Circle No. 179

PRINTER. The 753-10 nonimpact printer is a desktop, thermal, serial-character unit which uses a single 5×7 dot-matrix print head. The device produces copies of messages directed to it by the μP controller within the 751-10 display terminal. The 753-10 quietly prints up to 30 characters/sec in 80 columns on thermally sensitive paper. Functions include LF, CR, space, back space, character print and NOP on null and undefined codes. $2540. **Control Data Corp.,** Box O, Minneapolis, MN 55440. Phone (612) 853-4656. **Circle No. 180**

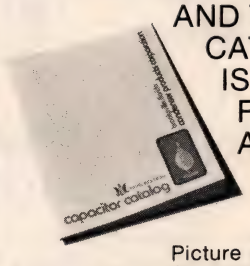


CALCULATOR. The SR-51-II has 8 memory registers—twice the number of its predecessor, the SR-51A. TI's Algebraic Operating System allows equations to be entered as they are algebraically stated, (including up to 9 parentheses sets and 5 pending operations). Seven conversion keys are offered, as well as other significant improvements. A rechargeable battery pack, AC adapter/charger and carrying case are also included. $79.95. **Texas Instruments Inc.,** Box 5012/MS 308, Dallas, TX 75222. Phone (214) 238-3741. **Circle No. 181**

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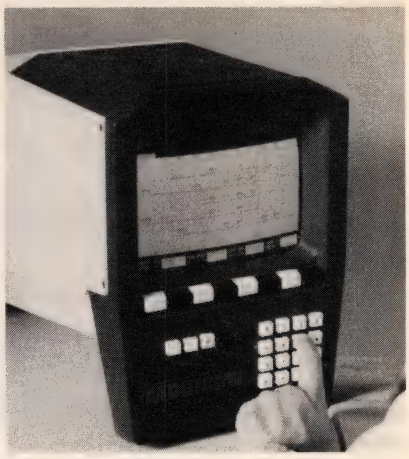
For more information, Circle No. 55



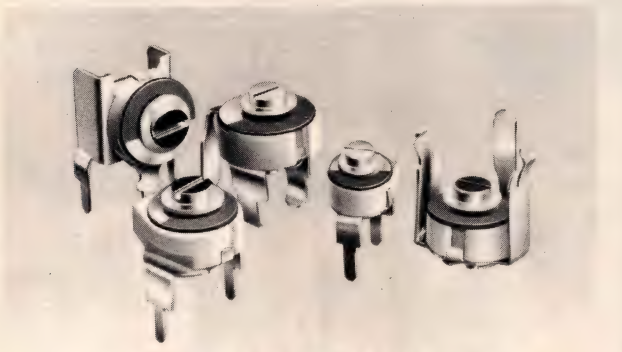
DATA TERMINAL. This Touch-Tone™ pad pocket data terminal can signal over telephone lines for data entry and remote programming, EBS testing, automatic dialing and security systems. Measuring 2.1×4.5×0.88 in. and weighing 5.5 oz, the unit generates all 16 pairs of standard touch-tone, dual-tone audio frequencies, yet cannot be modified to generate the illegal (bluebox) frequencies. The low-power CMOS uses a 9V battery. PDT-700, $49.95. **Executive Devices,** 740 S. Locan, Fresno, CA 93727. Phone (209) 255-6977. **Circle No. 182**

ANALOG EXTENSION. The AEU-1, a phase-correcting interface buffer, may be used between a DDS DSU and a synchronous modem, or between an unbuffered multiplex port of a high-speed (9600 bps) synchronous modem and one operating at the speed of the multiplexed port. The unit features analog extension of DDS circuits and of the unbuffered multiplexer output of a higher speed modem; as well as positive frequency and phase lock to DDS. **General DataComm Industries Inc.,** 131 Danbury Rc., Wilton, CT 06897. Phone (203) 762-0711. **Circle No. 183**

TABLET INTERFACES. Interfacing Summagraphics™ data tablets to the Tektronix 4051 graphic calculator is possible with these devices, enabling the transfer of X-Y coordinates to the calculator. All status bits, control functions, and handshaking signals are transmitted. Models conform to IEEE standards and can interface with HP calculators and the IBM 5100. HW-Series interface, $700; ID-Series interface, $450. **Summagraphics Corp.,** Box 781, Fairfield, CT 06430. Phone (203) 384-1344. **Circle No. 184**



PROGRAMMER. Programming, debugging and editing of Modicon programmable-controllers (PC) programs are easier with the Universal Programming Panel (UPP) Model P140. The UPP, claimed to be the first CRT programming panel for on-line use, permits program editing of complete circuits on the CRT, while the PC runs. Once changes are made, a single button updates the PC program. **Modicon Corp.,** Box 83, Shawsheen Village Station, Andover, MA 01810. Phone (817) 475-4700. **Circle No. 185**



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These rotary ceramic disc trimmer capacitors are perfect for broadband applications from audio to 500 MHz. They provide an ideal low cost means of "trimming" circuitry such as crystal oscillators, CATV amplifiers and all varieties of communication and test equipment.

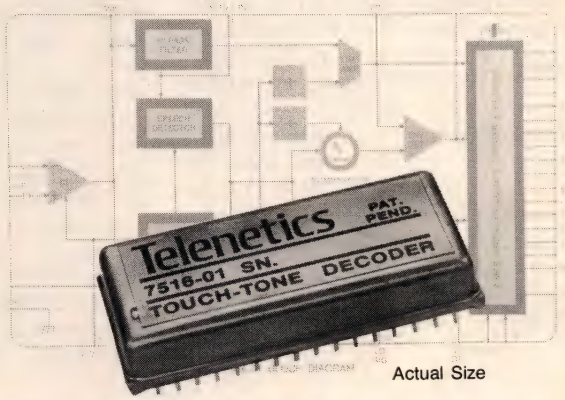
These capacitors are available in three adjustment configurations: top tuning, side tuning for "in rack" adjustment and bottom tuning for "thru the board" adjustment. Three mounting configurations allow drop in replacement for other types of units.

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For more information, Circle No. 56

TOUCH-TONE*



Actual Size

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Telenetics 7516-01 gives you one-tenth the size at one-third the cost of comparable Touch-Tone Receivers. Telenetics also offers these other devices:

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- 7511 Address Selector
- 7507 A complete line of Multiplexers and Analog Switches
- 7635 Touch-Tone Keyboards

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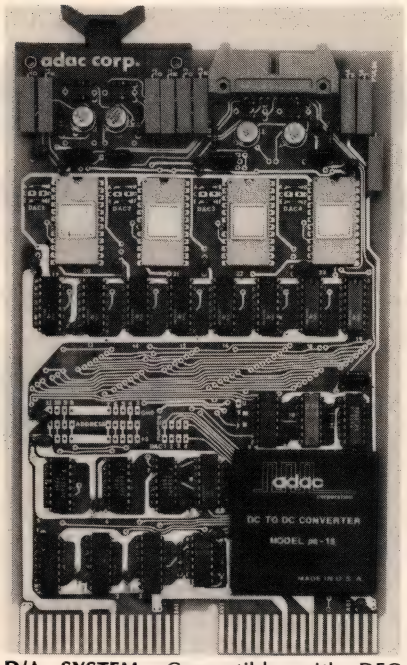
Telenetics, Inc., 4120 Birch Street,
Newport Beach, California 92660
Phone: (714) 752-6363

*R-Registered trademark of AT&T

For more information, Circle No. 57



RECORDING SYSTEMS. Series SE 7000 portable mag-tape instrumentation recording systems feature direct record/reproduce bandwidths to 1 MHz with input sensitivity of 0.1 to 2.5V rms, 20 kΩ input impedance, 75Ω output impedance and 1V rms output. The unit records pulse-code modulated (NRZ L) signals at rates to 1M bits/sec, is TTL compatible and has 8 switch-selectable speeds from 15/16 to 120 in./sec. $15,000. **EMI Technology Inc.,** 20 Old Ridgebury Rd., Danbury, CT 06810. Phone (203) 744-3500. **Circle No. 186**



D/A SYSTEM. Compatible with DEC LSI-11 and PDP-11/03 μC's, the Model 600-LSI-11D consists of from 1 to 4 12-bit D/A converters on a single 5×8.5-in. board. A bus interface, dc/dc power converter, and scope control are also on the card. The scope control allows visual display of actual data without the display of extraneous data that normally occurs during DAC updating. $850 with 4 DAC's. **Adac Corp.,** 15 Cummings Park, Woburn, MA 01801. Phone (617) 935-6668. **Circle No. 187**

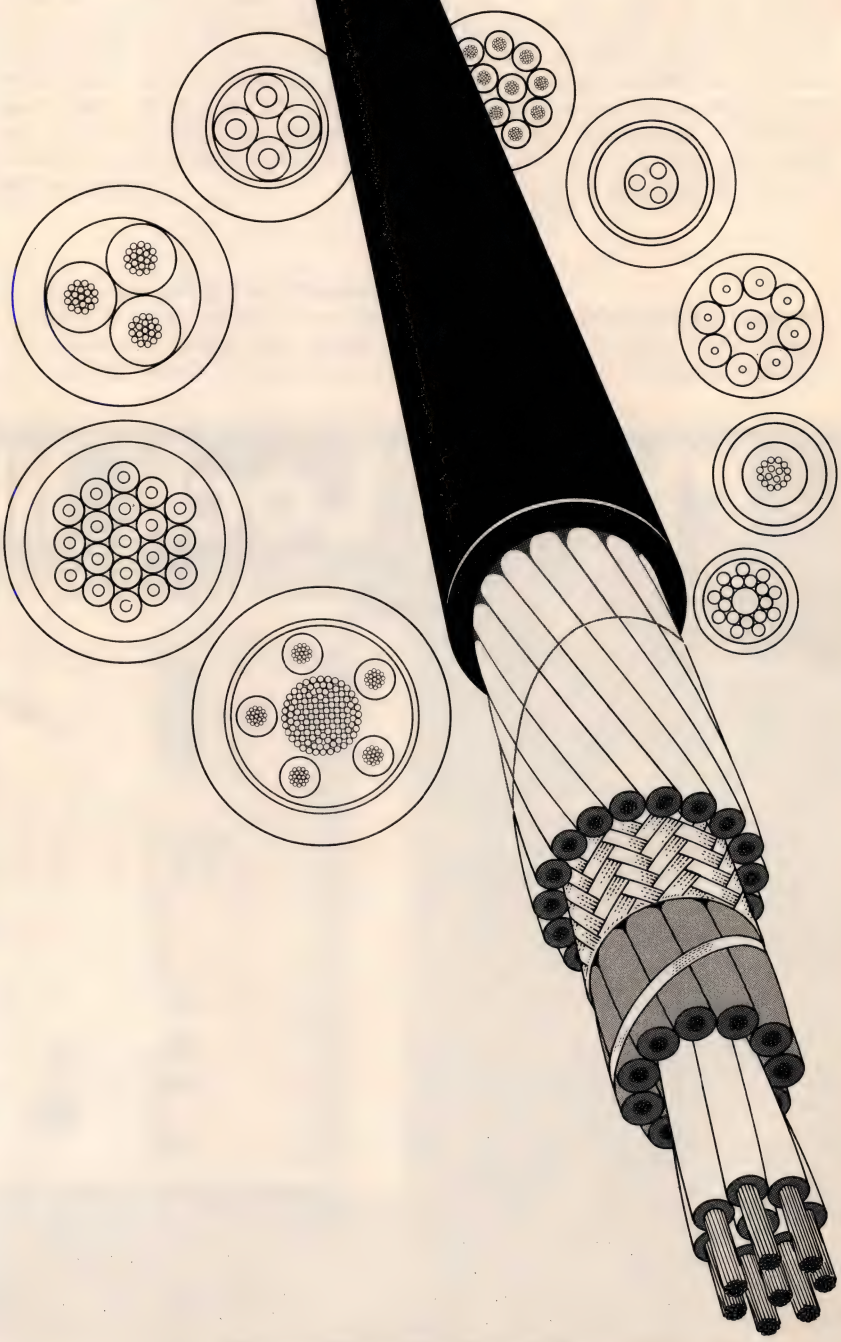
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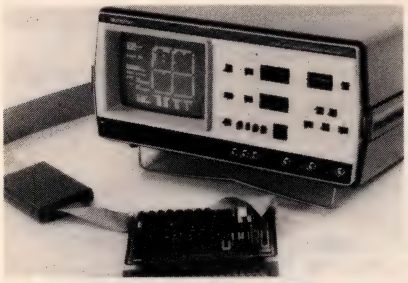
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For more information, Circle No. 46

INSTRUMENTATION/POWER SOURCES



MICROPROCESSOR ANALYZER. Model 168-D records a history of up to 256 memory accesses, beginning with a preselected 16-bit Start event and/or ending with a preselected 16-bit Stop event. Recorded information is presented on a 9-in. CRT. A unique personality module for each type of μP connects the μP system with the 168-D (versions for 8080A and 6800 are available now). $5650, complete with one personality module and hookup cable. **Biomation Corp.,** 10411 Bubb Rd., Cupertino, CA 95014. Phone (408) 255-9500.
Circle No. 188

CHART RECEIVER/RECORDER for unattended CATV measurements, the 5 to 400-MHz Model 9021 has a built-in timer (for 1/4, 1/2, 1 and 2-hr intervals) and provides 24-hr unattended operation from 1 full automotive-battery charge. It measures system frequency response, carrier levels by wide-band spectrum analysis and spurious signals by narrow-band spectrum analysis. DC supply current is 350 mA standby, 2.5A recording. $1895. **Kay Elemetrics Corp.,** 12 Maple Ave., Pine Brook, NJ 07058. Phone (201) 227-2000. **Circle No. 189**

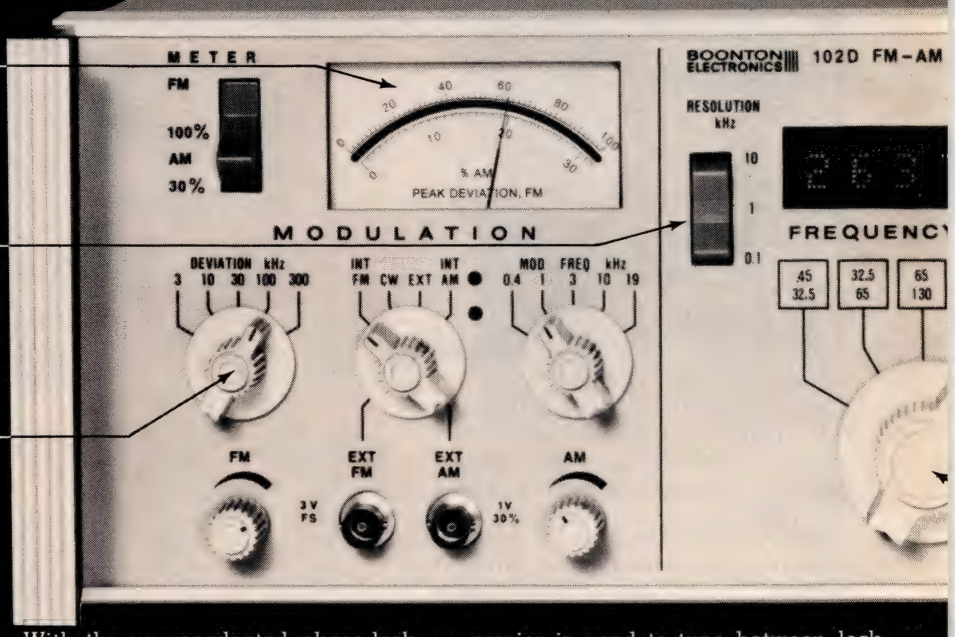
POCKET COUNTER. The Pocket Counter III features a 0.3-in., 7-digit LED readout, frequency range of 1 Hz to 10 MHz, better than 250-mV sensitivity and accuracy of 0.001% + 1 count. Four AA nickel-cadmium batteries power it for 8 hrs. at 30% duty cycle. $189. **Logic Technology Inc.,** 1950 Colony St., Mt. View, CA 94043. Phone (415) 967-1007.
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SNAP-AROUND VOM. Model SPR-930 features 3% accuracy from 50 to 400 Hz. Compact and rugged, it presents only 1 range at a time. Ranges include 10 to 900A, 150 to 750V and 25Ω midscale. Case, leads, fused battery attachment for ohms, instructions and warranty are included. **A.W. Sperry Instruments Inc.,** 245 Marcus Blvd., Hauppauge, NY 11787. Phone (516) 231-7050. **Circle No. 191**



WIDE-BAND RF AMP. With a typical 3-dB bandwidth of 0.5 to 2500 MHz and output power of +17 dBm for 1-dB gain compression, Model 2101 can improve the sensitivity of RF measurement instruments and enhance the power capability of signal sources such as sweep and signal generators. Specs show 30-dB gain, flat within ±1 dB to 1000 MHz and ±1.5 dB to 2400 MHz. $725. Delivery, 60 days ARO. **Wavetek Indiana, Inc.,** 66 N. First Ave., Beech Grove, IN 46107. Phone (317) 783-3221.
Circle No. 192

Phase Lock like you've

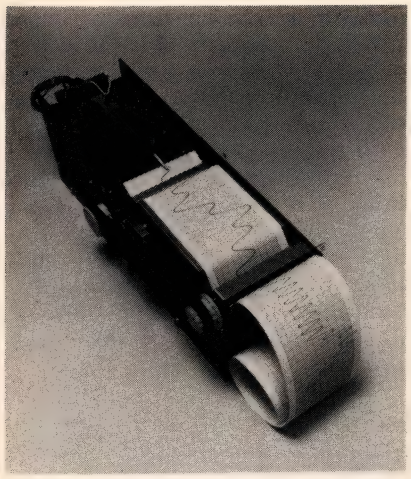


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Simple—you not only extend the frequency range to cover 450 kHz to 520 MHz, but you make sure that the frequency you see is the frequency you get ... exactly. (And virtually indefinitely.)

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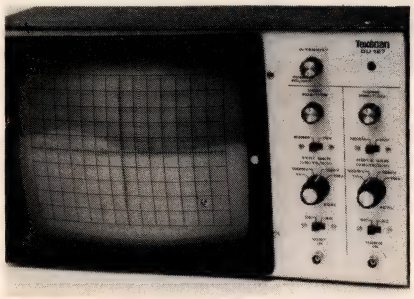
No one else makes it that easy, even in generators selling for $2100 more. But



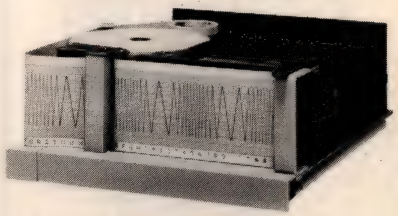
OEM PORTABLE RECORDER. The single-channel 102 XLA draws only 6W from a 12V dc source. Its stylus operates directly from the power source, and the position-feedback galvanometer provides over-all accuracy of 1/2% of F.S. Thermal writing on 50-mm paper and immediate visibility of the trace are featured—along with dimensions of only 4×6×6-1/4 in. $425. **Astro-Med,** Atlan-Tol Industrial Park, West Warwick, RI 02893. Phone (401) 828-4000.

Circle No. 193

DUAL RECORDER/INTEGRATOR monitors the output of solar panels and similar devices for up to a month, unattended. The battery-powered Model R-2TL/101A/WP/B has 2 separate integrator channels, each with input ranges between 10 mV and 100V—together with a dual-channel recorder, 6-digit counters and built-in calibration. **Tecnico Electronics,** Box 12, Marrickville, Sydney, Australia. 2204. **Circle No. 194**

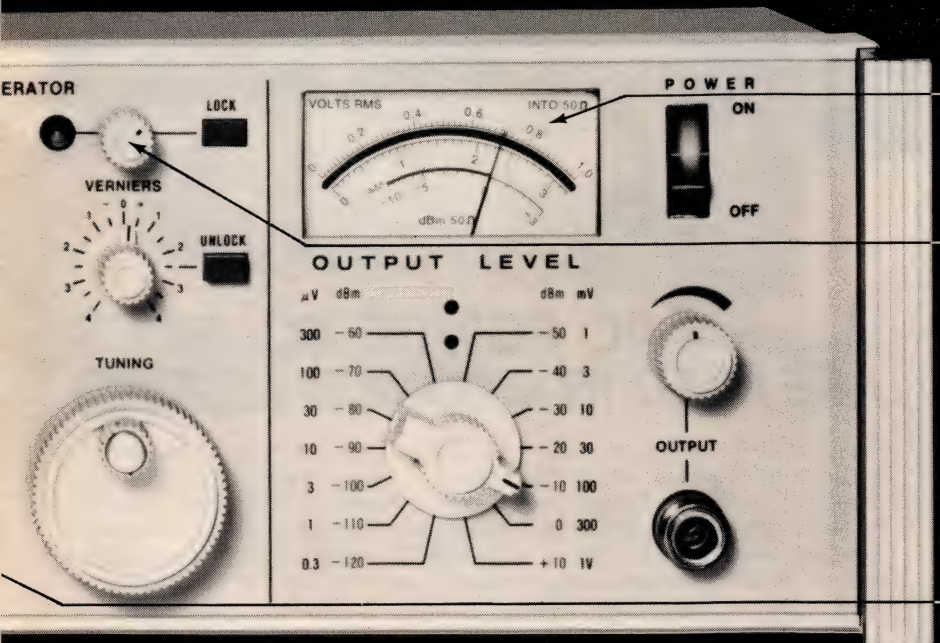


DISPLAY SCOPE. Its 12-in. CRT, equal bandwidth on X and Y axes, low-drift dual FET input and 1-mV sensitivity fit the DU-127 for sweep RF testing with frequency markers, and data display that requires Z-axis modulation. The unit measures 17×9-1/2×15-1/2 in. and weighs 25 lbs. $650. Delivery, 6 weeks ARO. **Texscan Corp.,** 2446 N. Shadeland Ave., Indianapolis, IN 46219. Phone (317) 357-8781. **Circle No. 195**



RECORDER/PRINTER. The OEM MED-110 oscillographic recorder simultaneously records analog signals and prints alphanumeric data: A thermal stylus performs the analog recording on rectilinear chart paper, while a thermal print head puts the alphanumeric data in the lower chart margin. Amplifier, power supply and transformer must be user supplied. **Gulton Industries, Inc.,** East Greenwich, RI 02818. Phone (401) 884-6800. **Circle No. 196**

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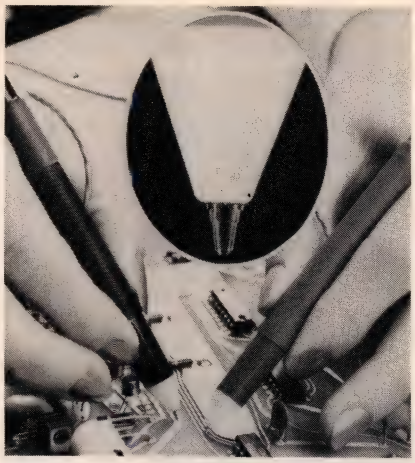
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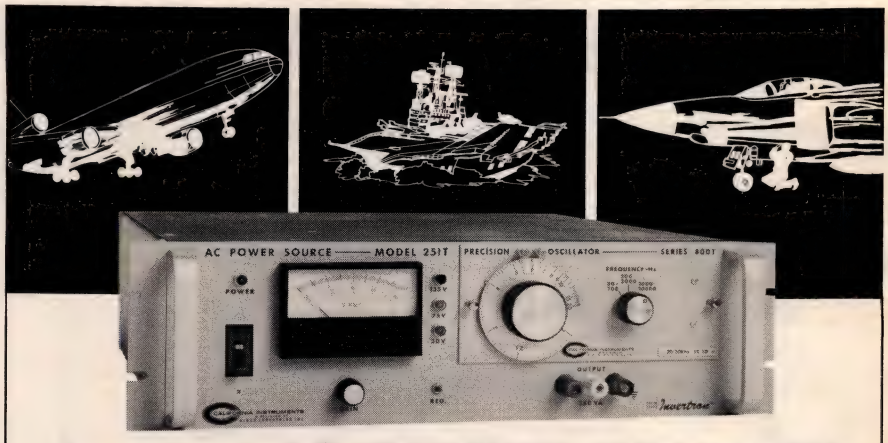
INSTRUMENTATION/POWER SOURCES



MICROCIRCUIT PROBES. Designed for true 4-terminal resistance measurements on microcircuits when used with the Model 1700 digital ohmmeter, these are small enough to probe a pad only 20×20 mils in size. Probe tips are spring-loaded into a pen-sized holder for easy manipulation and simple replacement. They easily isolate pc-board slivers, shorts in IC's and open conductor stripes under DIP's. $95. **Electro Scientific Industries, Inc.,** 13900 N.W. Science Park Dr., Portland, OR 97229. Phone (503) 641-4141. **Circle No. 197**

CAPACITOR-LEAKAGE TESTER. Model TPP-15 is intended specifically for operation in conjunction with a mechanical-handling and routing machine, forming a fully automatic system for the testing and binning of ceramic-capacitor chips by their dc leakage values. Chips are precharged with dc, tested to a programmed current limit, then discharged and routed to bins. $2450. **Telepacific Electronics Co., Inc.,** Box 2210, Escondido, CA 92025. Phone (714) 744-4415. **Circle No. 198**

MONITOR/SIMULATOR. The Pacer-103, a portable data-line unit, gives a first-hand look at the data stream at the RS-232 interface, displaying the results in a 32-char. alphanumeric window (and a 2-char. hex display). In the monitor mode it captures and stores 1024 transmitted or received characters on full- or half-duplex lines. In the simulate mode, it generates a variable test message that appears to the network as coming from a terminal or modem. $7400. Delivery, 120 days ARO. **Digitech Data Industries, Inc.,** 66 Grove St., Ridgefield, CT 06877. Phone (203) 438-3731. **Circle No. 199**



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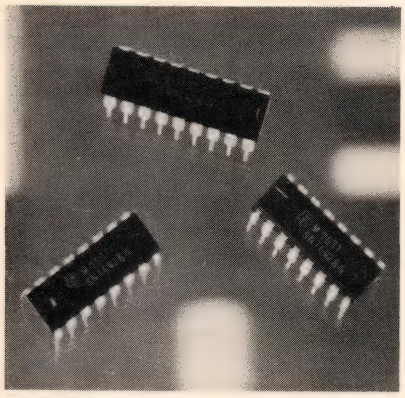
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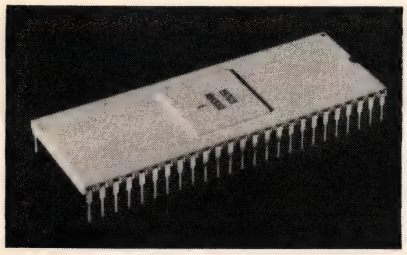
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IC'S/SEMICONDUCTORS



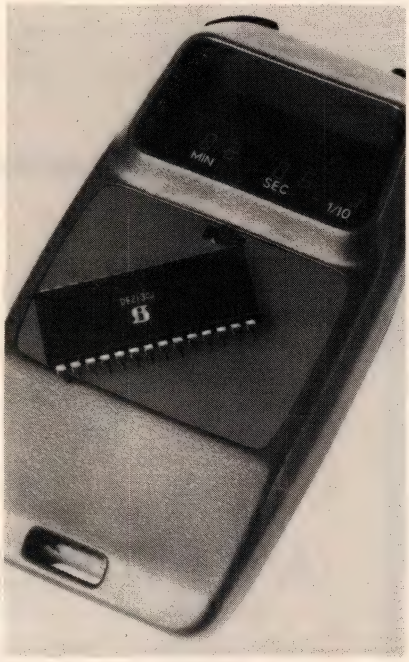
VIDEO GAME IC'S. Combinations of circuits from this IC family allow games with multiple balls, multiple walls, multiple players and obstacles. The chips can serve for simple tennis and hockey or for more intricate games such as race, battle, complex soccer, pool, and pin ball. The first 6 circuits—to be supplemented by new IC's—include the SN76423 (game logic with automatic-random English), SN76427 (wall and ball generator) and SN76460 (0 to win at 20 digital scoring). SN76423, $1.25; SN76427, $1.53; SN76460, $4.54 (100). **Texas Instruments Inc.,** Box 5012, M/S 308, Dallas, TX 75222. Phone (214) 238-2481. **Circle No. 200**

DISPLAY DRIVERS. Models DS8871, 8872, 8873 and 8977 bipolar IC's can interface between MOS calculator circuits and common-cathode LED displays with digit current to 40 mA. DS8871 is an 8-digit driver; DS8872, a 9-digit driver; and DS8873, a 9-digit driver with a built-in battery-condition indicator. DS8977 is a 7-digit version of the DS8873. 8871, $1.40; 8873, $1.60 (100). **National Semiconductor Corp.,** 2900 Semiconductor Dr., Santa Clara, CA 95051. Phone (408) 732-5000. **Circle No. 201**



BIPOLAR μP. This fixed-instruction set, high-speed μP, the 8×300, is intended for control applications (such as peripheral controllers, CRT terminals and video games) and designed with a dual-purpose address-data bus partitioned into a right and left bank. The simple double-operand instruction set makes the chip suitable for use in a CPU where 8-bit parallel data can be accessed and processed in a single 250-nsec instruction cycle. $86.75 (100). **Signetics,** 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (714) 739-7700. **Circle No. 202**

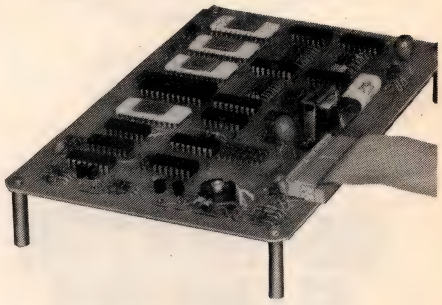
REGISTER STACK. The 9405A arithmetic-logic register stack (ALRS), an addition to the Macrologic 4-bit slice family, is said to be the fastest 4-bit TTL slice currently available and is guaranteed to operate with a 75-nsec clock period—30 nsec faster than the nearest competitive circuits. The register stack utilizes a 2-address architecture, in which addresses are multiplexed. $12 (100). **Fairchild Camera and Instrument Corp.,** 464 Ellis St., Mt. View, CA 94042. Phone (415) 962-3816. **Circle No. 203**



STOPWATCH CIRCUITS. The DF213 and 214, said to be the first digital stopwatch IC's that operate as dual timing systems, allow a single electronic stopwatch (operated from a standard 3.2768-MHz crystal) to replace 2 conventional stopwatches in sports and engineering applications. The DF213 clocks up to 59:59.99 min., "rolls over" to zero and continues to count; the DF214 clocks up to 99.999 min., goes to zero and continues to count. DF213 or 214, $9.80 (100). **Siliconix,** 2201 Laurelwood Rd., Santa Clara, CA 95054. Phone (408) 246-8000. **Circle No. 204**

MSC® Low Cost Voice Readout System (VRS)





Solid-State Voice . . .

Up to 16 Natural-Sounding Words Per Circuit Board

The MSC Model 1700 Voice System contains everything for up to 16 words of high-fidelity voice readout on one circuit board. A second circuit board may be added to increase vocabulary up to 32 words. The system may be purchased as a circuit board only or provided with an enclosed package.

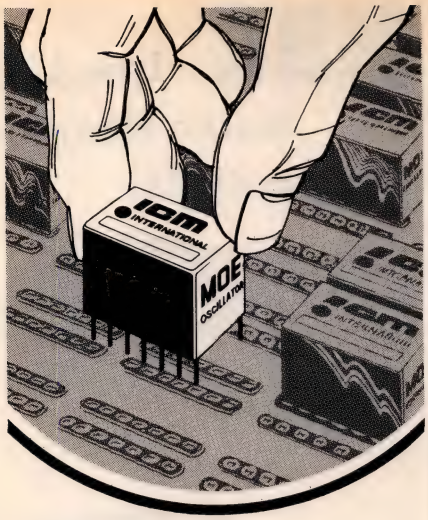
Each word is stored in a Read-Only Memory (ROM). The result of this whole word storage is a voice so natural-sounding, it is difficult to distinguish it from the original recording. It is a simple matter to access each ROM to call up the words in the sequence required for the desired message, without complicated programming.

The Model 1700 accepts either binary address or 10 mutually exclusive switch closures.

Write for descriptive data sheet now!

MSC® MASTER SPECIALTIES COMPANY
1640 Monrovia, Costa Mesa, California 92627
Phone (Area Code 714) 642-2427

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INTERNATIONAL'S

moe CRYSTAL OSCILLATOR ELEMENTS

A Complete Controlled Signal Source from 6000 KHz to 60 MHz

The MOE series is designed for direct plug-in to a standard dip socket. The miniature oscillator element is a complete source, crystal controlled, in an integrated circuit 14 pin dual-in-line package with a height of ½ inch.

Oscillators are grouped by frequency and temperature stability thus giving the user a selection of the overall accuracy desired. Operating voltage 6 vdc. Output wave shape — non sine.

MOE-5
Crystal Range
6000 KHz to 60 MHz
OVERALL ACCURACY
+.002% -10° to + 60°C
25°C Tolerance
Zero Trimmer
$35.00

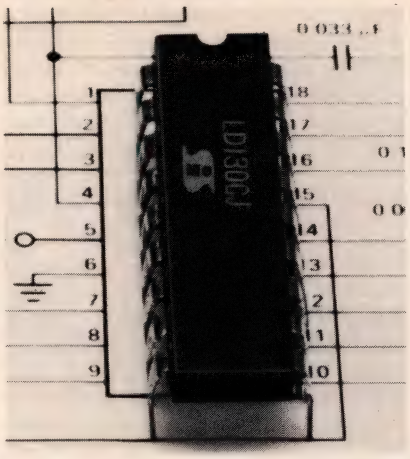
MOE-10
Crystal Range
6000 KHz to 60 MHz
Overall Accuracy
+.0005% -10° to 60°C
25°C Tolerance
Zero Trimmer
$50.00

ICM

International Crystal Manufacturing Company, Inc.
10 North Lee, Oklahoma City, Oklahoma 73102

For more information, Circle No. 62

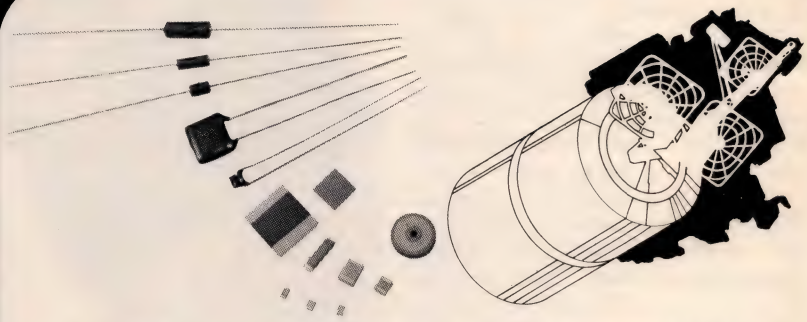
IC'S/SEMICONDUCTORS



DIGITAL VOLTMETER. The LD130, a CMOS device claimed to be the first 3-digit IC DVM, maintains typical accuracy of ±0.1% ±1 count with standard 10%-tolerance RC components and a single reference, which can be established by a standard zener. A single or split 10V supply may be used. The 18-pin DIP also provides automatic polarity reversal and range-changing. Automatic zeroing intervals are featured. $8.75 (100). **Siliconix,** 2201 Laurelwood Rd., Santa Clara, CA 95054. Phone (408) 246-8000. **Circle No. 205**

LINE DRIVER. Dual line driver 7150 interfaces data terminals and communications equipment per RS-232C. Using this circuit, a rate of 20,000 bps can be transmitted with a full 2500-pF load. The input is TTL and DTL compatible, and operation is from +12 and −12V supplies. Ceramic DIP 75150DC, $2.07; plastic DIP 75150PC, $1.72; ceramic mini-DIP 75150RC, $2; plastic mini-DIP 75150TC, $1.67 (100). **Fairchild Camera and Instrument Corp.,** 464 Ellis St., Mt. View, CA 94042. Phone (415) 962-3816. **Circle No. 206**

POWER FET'S. A series of 6 VMOS MOSPOWER™ FET's become fully linear at 400 mA and remain so to over 2A. One CMOS output can control 100 MOSPOWER transistors. VMP 1, 11 and 21 are 25W general-purpose power FET's; VMP 2, 12 and 22 are 4W FET's. The units, which can replace Darlingtons, are spec'd for max. continuous drain current of 2A (VMP 1) and switching speed of 4 nsec, and have breakdown ratings from 35 to 90V. $3.60-$8.10 (100). **Siliconix,** 2201 Laurelwood Rd., Santa Clara, CA 95054. Phone (408) 246-8000. **Circle No. 207**



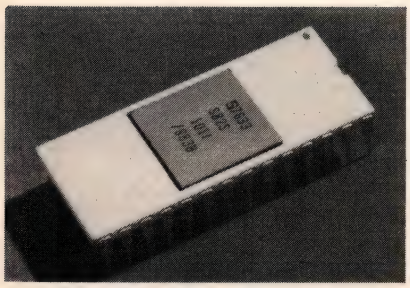
A New High in Stability

Centre Engineering has met the challenge of providing ultra-high reliable sub-minature ceramic capacitors for the space programs. Now, design engineers in the tele-communications, computer and instrumentation industries can have ceramic capacitors in high volume for low cost applications, using the same processes and manufacturing techniques from Centre Engineering.

Ceramic capacitors are available in 40 various formulations with a capacity range of 1pf to 10mfd. For applications requiring large volume, low cost ceramic capacitors consider Centre Engineering. Catalog available upon request.

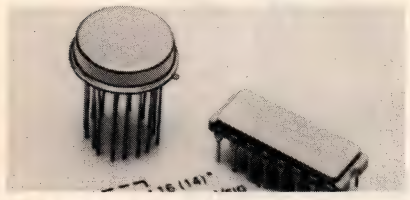
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814—237-0321 ■ TWX 510—670-3517

For more information, Circle No. 63



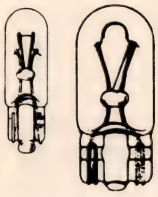
MIL-RANGE FPLA'S. Both the S82S100 tri-state output device and the S82S101 open-collector version feature single 5V-supply operation, 80-nsec max. access time and 48 product terms. Their 16×8 I/O configuration allows direct manipulation of 2 data bytes and provides the capability to scan a 65k-word address field. A chip-enable input eases the expansion of input and product terms. The MIL-STD-883B processed units come in 28-pin, ceramic DIP's. S82S100, $48; S82S101, $54.25 (100). **Signetics,** 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **Circle No. 208**

8-BIT REGISTERS. These low-power SIPO shift registers have tri-state outputs and offer 4 operation modes: hold, shift left, shift right and load data. Am25LS23 has a synchronous clear function; Am25LS299, an asynchronous clear. The Am54/74LS299 is a reduced-performance version of the Am25LS299. All units are spec'd for commercial and military temperatures and come in molded and hermetic DIP's. $4.30-$8.35 (100). **Advanced Micro Devices Inc.,** 901 Thompson Pl., Sunnyvale, CA 94086. Phone (408) 732-2400. **Circle No. 209**



FET ANALOG GATES. Capable of switching up to ±10V signals directly from DTL or TTL and providing high logic-noise immunity (typically 1V), these 2 general-purpose quad FET gates turn off faster than they turn on, allowing multiplexing without shorting. Models CAG-50D and 50T provide the advantages of small size and full military temperature range. 50D or 50T, $29 (100). **Teledyne Crystalonics,** 147 Sherman St., Cambridge, MA 02140. Phone (617) 491-1670. **Circle No. 210**

General Electric wedge base lamps can save time, space, money.

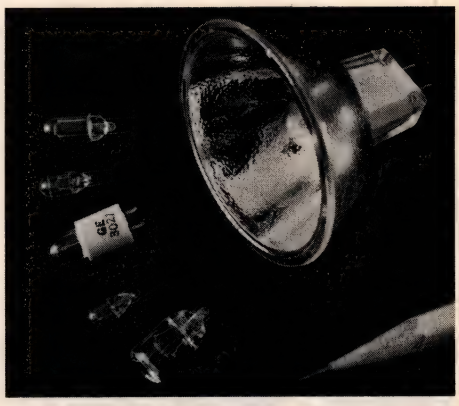


These lamps are ideal for applications such as indicators, markers and general illumination where space is at a premium. Their wedge-based construction makes them easy to insert and remove. They don't require bulky, complicated sockets. And because the filament is always positioned the same in relation to the base, you get consistent illumination from lamp to lamp.

You can choose from over 25 types of GE wedge base lamps. Voltages range from 6.3 V to 28 V. Candlepower from 0.03 to 12 cd. Bulb sizes range from subminiature at 6mm to a heavy-duty bulb at 15mm.

To send for updated wedge base lamp technical information, circle number below or write GE for Bulletin #3-5259.

Check these 6 halogen cycle lamps GE has added to its low-voltage line.

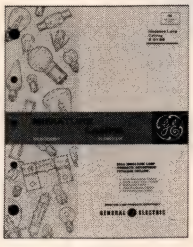


General Electric now offers over 27 halogen cycle lamps that pack high light output in small packages. (In addition, GE offers 8 sealed beam halogen lamps primarily for aircraft applications.) Bulb diameters range from 3/16" to 1/2". Lengths from .520" to 2.25". Voltages from 3.5 to 28. O.V. And candlepower from 2.15 cd up to 250 cd.

They're ideal for you if you're designing applications such as optical systems, instrumentation, illuminators, fiber optics, card readers, displays and aircraft navigation. A variety of terminals are offered.

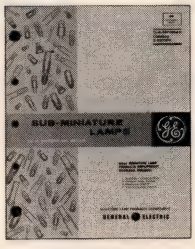
For updated technical information circle the number below or write GE for Bulletin #3-5357.

These three free GE catalogs include important data changes that could affect your present design. Send for yours today.



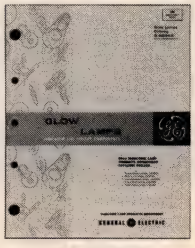
#3-5169

June '75 Miniature lamp catalog features 40 pages and 500 data changes for complete 500-lamp line.



#3-6252R1

Feb. '75 Sub-miniature lamp catalog features 24 pages and 91 changes for more than 210 lamps.



#3-6254R

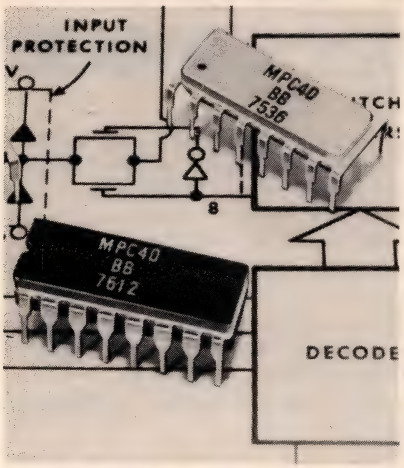
Dec. '74 Glow Lamp catalog features 8 pages and 50 changes for 83 Glow Lamp Indicator and Circuit Component lamps.

For up-to-date technical information on any of these items write: General Electric Company, Miniature Lamp Products Department #3382-K, Nela Park, Cleveland, Ohio 44112.

GENERAL ELECTRIC

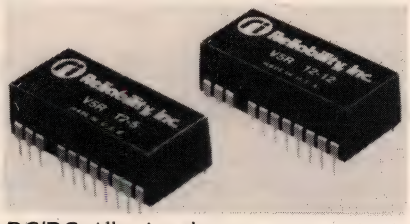
For more information, Circle No. 64

MODULES/SUBASSEMBLIES

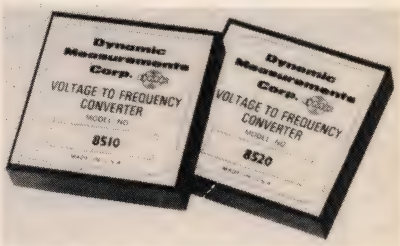


MULTIPLEXERS. Providing 20V input-overvoltage protection, Model MPC4D (4-channel differential) and Model MPC8S (single-ended 8-channel) both feature CMOS construction for low power dissipation of 7.5 mW standby and 15 mW at 100 kHz. Both units employ break-before-make switching; and provide sampling rates to 200 kHz, 500-nsec typical access time, and accuracy compatible with 12-bit systems. $14. **Burr-Brown,** International Airport Industrial Park, Tucson, AZ 85734. Phone (602) 294-1431. **Circle No. 211**

D/A, A/D. Model DBK, a 12-bit D/A designed to meet MIL-M-28787, allows ±4-LSB accuracy and comes in 3 voltage ranges (12, 5 and 2.5V, unipolar or bipolar) with voltage output settling in < 3 μsec; current output settles in 600 μsec. Model DBL, in conjunction with Model DBK, provides the successive-approximation logic to allow a 12-bit A/D conversion in 6.6 μsec. **Raytheon Co.,** Submarine Signal Div., W. Main Rd., Portsmouth, RI 02871. Phone (401) 847-8000. **Circle No. 212**



DC/DC. Allowing the power source to sit on the same board as the IC's powered, these devices, mounted in 24-pin DIP's, provide ±12V or +12V and −5V from a 5V input (also available for 12V inputs), drawing 1W max. Claiming typical efficiency of 65%, the V-PAC family features 30-mV p-p output ripple and noise (over 20 Hz to 20 MHz), 0.3% load regulation, and ±5% output tolerance. $38.20. **Reliability, Inc.,** 5325 Glenmont, Houston, TX 77036. Phone (713) 666-3261. **Circle No. 213**



V/F. Available in 3 frequency ranges (10, 20 and 100 kHz), 12 models of the 8001 family provide 13-bit resolution, max. offset TC of 20 μV/°C, max. gain TC of 50 ppm/°C, and linearities to within 0.025% of F.S. max. Operating from a +15V supply, these converters output a string of fixed-width, logic-compatible pulses at a rate proportional to the analog input. Price, below $30. **Dynamic Measurements Corp.,** 6 Lowell Ave., Winchester, MA 01890. Phone (617) 729-7870. **Circle No. 214**

NEW DAVCO LOGIC/WAVEFORM ANALYZER

Model DM 230



Now a simple, reliable, easy to operate logic/waveform analyzer for μ computer system development and trouble shooting.

Features:

Data Domain

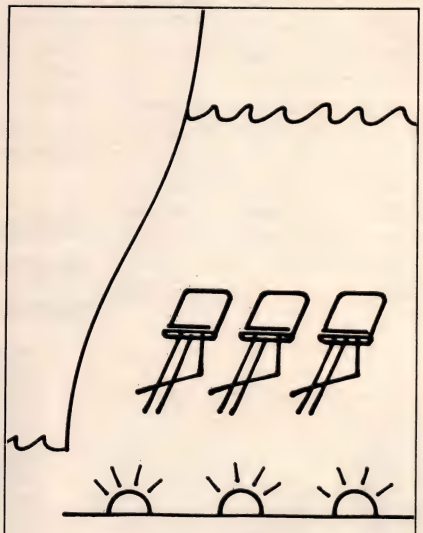
- 32 bit wide x 256 word long built-in memory system.
- Start or end trigger hexadecimal address, stored data displayed on a 6 digit hexadecimal display.
- Optional printer output available.

Time Domain

- Real time analog scope display of micro processor bus information up to 32 separate channels.
- Rapid time domain response of the analog channels allows the system rise/fall time and pulse timing information to be readily observed. Write or call.

DAVCO MANUFACTURING CO.
169 Ridgedale Ave., Morristown, N.J. 07960
(201) 267-4990

For more information, Circle No. 65



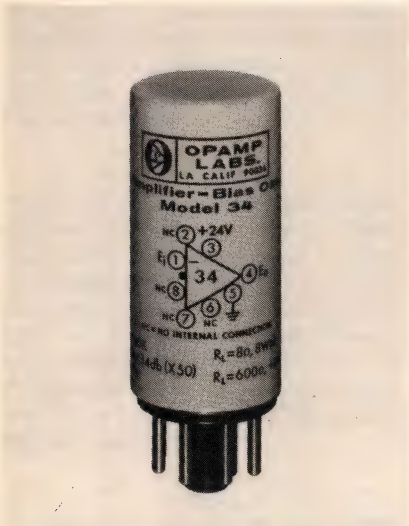
Star Performers

Our 10.7 and 21.4 MHz standard monolithic crystal filters are getting standing ovations. These models — over 50 — will perform for you, too. Like a review? Just write or call.

The Standard in Monolithic Crystal Filters

Piezo Technology Inc.
2525 Shader Road, Orlando, Fl. 305-298-2000

For more information, Circle No. 66



AMP/BIAS OSCILLATOR. Dual-purpose Model 34, suitable for use in general-purpose signal-processing and audio applications, provides a 34-dB gain over the frequency range of 20 Hz to 20 kHz (±2 dB) with 0.25% THD (+18 dBm). The unit, housed in a 1-in. diameter, 2-in. high octal plug-in, also can output 20V rms through a 1-kΩ load when operating as a 100-kHz oscillator. $20. **Opamp Labs Inc.,** 1033 N. Sycamore Ave., Los Angeles, CA 90038. Phone (213) 934-3566.

Circle No. 215

MATH MODULE. Internal programming dictates which function the Model A-733J will perform: multiplication, division, square root, squares or powers. With minimal external circuitry, the unit also handles true-RMS, absolute-value or vector-magnitude functions. Input level may range from 100 mV to 10V, keeping processing errors below 0.5% F.S. without external trimming. $70. **Intech Inc.,** 282 Brokaw Rd., Santa Clara, CA 95050. Phone (408) 244-0500.

Circle No. 216

LINE REGULATORS. With their 98% efficiency providing significant power savings and reduced heat dissipation, the 75-Series regulators protect against line voltages that dip 20% below normal, while regulating output to within ±5% of nominal. These devices correct variations in <1 cycle, limit THD to <0.1%, and come with power ratings from 600 VA through 20 kVA (1ϕ), and 6 kVA through 100 kVA (3ϕ). Prices from $265. **Topaz Electronics,** 3855 Ruffin Rd., San Diego, CA 92123. Phone (714) 279-0111.

Circle No. 217

Agnes, for one minute will you try to forget CAPAR's Tantalum Dips? I know CAPAR's got one of the largest inventories and their products are reliable and their service is great. But there is a time and place for everything.

Henry, get off my foot.



It's hard for some people to put CAPAR's Tantalum Dips out of their thoughts. Because for an application that requires low cost, high capacitance, and small size tantalums, there are none quite like CAPAR's.

Our tantalum Dips are manufactured for high reliability (from –55°C to +85°C) at low cost. Their electrostatic epoxy powder coating ensures protection from severe moisture.

CAPAR has one of the largest inventories of tantalums in the industry. And that's not all. We manufacture radial and axial aluminum electrolytics, radial polyester film capacitors, radial and axial metallized film capacitors and carbon film resistors.

Why not send for more information about our complete line of components? Once you've tried us, we know you'll like us.



CAPAR COMPONENTS CORPORATION

303 Crossways Park Drive, Woodbury, New York 11797; Telephone (516) 364-2610; (800) 645-7474; Telex No. 144678

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hot stuff

or cold, CHR's family of TEMP-R-TAPE of Kapton provides outstanding endurance. They retain their excellent mechanical and electrical properties over a wide temperature range, —100 to +500F.

Available in thicknesses from .001" to .0045" with a choice of several adhesive systems including two sides.

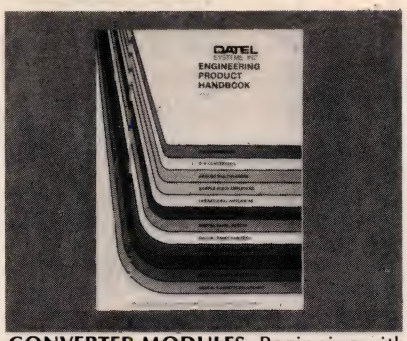
Find your CHR distributor in the Yellow Pages under "Tapes, Industrial" or in industrial directories. Or write for complete specification kit and sample. The Connecticut Hard Rubber Company, New Haven, Conn. 06509.

CHR

an ARMCO company

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LITERATURE

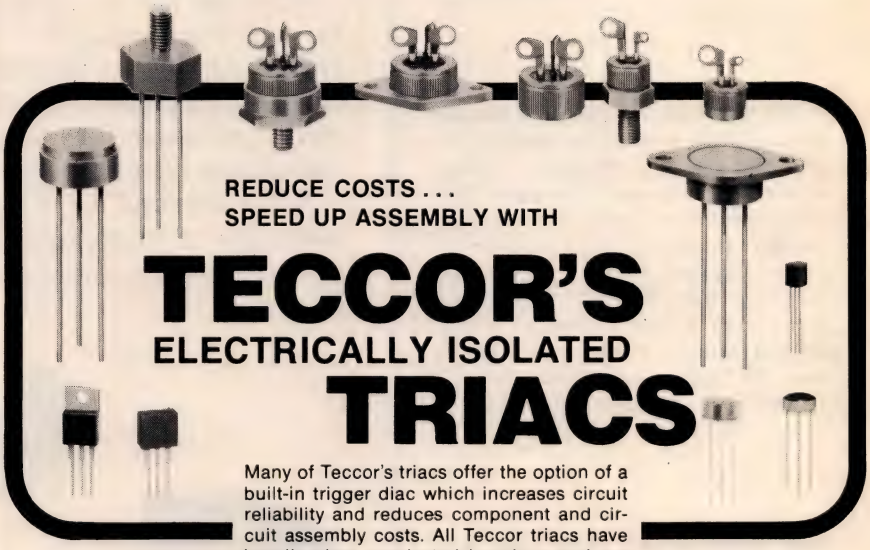


CONVERTER MODULES. Beginning with a 13-pg. tutorial on the principles of data acquisition and conversion, this 288-pg. engineering-products handbook gives detailed application material for many of the modules and instruments listed, and provides parameter-comparison charts for easy module comparison and selection. **Datel Systems, Inc.,** 1020 Turnpike St., Canton, MA 02021.
Circle No. 218

POWER SUPPLY efficiency as it relates to heat and reliability is thoroughly explored in this 6-pg. reprint of a technical article. Numerous sample calculations, warnings and hints are included, giving the system designer practical rule-of-thumb guidelines toward achieving effective thermal management. **Semiconductor Circuits, Inc.,** 306 River St., Haverhill, MA 01830.
Circle No. 219

SEMICONDUCTORS. A 40-pg. short-form catalog describes ITT's complete line of more than 2000 solid-state products. It lists electrical characteristics; package dimensions; charts and ordering data for linear, TTL and MOS IC's; interface circuits, and custom and discrete devices. **ITT Semiconductors,** 74 Commerce Way, Woburn, MA 01801.
Circle No. 220

THERMISTORS. Manual L-7 is designed specifically to assist engineers in the use of thermistors operated in the self-heat mode. It complements the discussion with detailed graphics, charts, working tables and practical solutions and/or answers to real-life problems. Units suitable for operation in the self-heat mode are also listed, along with their E-I curves. **Fenwal Electronics,** 63 Fountain St., Framingham, MA 01701.
Circle No. 221



REDUCE COSTS . . .
SPEED UP ASSEMBLY WITH

TECCOR'S ELECTRICALLY ISOLATED TRIACS

Many of Teccor's triacs offer the option of a built-in trigger diac which increases circuit reliability and reduces component and circuit assembly costs. All Teccor triacs have heavily glass passivated junctions and are undamaged by high voltage transients, thus assuring long device life. A wide selection of packages, current and voltage ratings are available.

TECCOR

TECCOR ELECTRONICS, INC.
(formerly ECC Corporation)
P.O BOX 669 EULESS, TEXAS 76039 817/267-2601

For more information, Circle No. 69



PANEL DESIGN. This layout-design guide discusses such considerations as: operator requirements, environmental factors, manual controls, visual displays and maintainability. Attention is also paid to "preferred" vs. "poor" design and to typ. layout considerations. Use of color in panel and control housing, coding and illumination is covered as well. The brochure concludes with a section on graphics. **Micro Switch,** 11 W. Spring St., Freeport, IL 61032.

Circle No. 222

LAMPS. Catalog 3-6016 contains specs and drawings on 194 different subminiature lamps, plus factors to consider in selecting the type to match the application. Also included are a section explaining halogen-cycle lamps and their advantages, a photo illustrating filament notching, drawings re-done in a more clear and sharp format, and lamp charts brought together on 1 pg. for easy reference. **General Electric Co.,** Nela Park, Cleveland, OH 44112.

Circle No. 223

DATA CONVERTERS. Two 8-pg. application notes list parameter definitions and error-calculation methods for A/D's (Bulletin AN-24) and D/A's (AN-25). These booklets also detail parameter-testing techniques the reader can duplicate on his own units. **Teledyne Philbrick,** Allied Dr. at Rte. 128, Dedham, MA 02026.

Circle No. 224

FREQUENCY STABILITY. "Three Techniques for Measuring and Interpreting Short-Term Frequency Stability," an 8-pg. applications bulletin, deals with microwave signal sources. After briefly discussing the nature of short-term instability, the author focuses on residual FM noise, SSB phase noise and phase jitter. He then describes and analyzes practical methods employing each parameter in turn. **Communication Techniques, Inc.,** 1279 Rte. 46, Parsippany, NJ 07054.

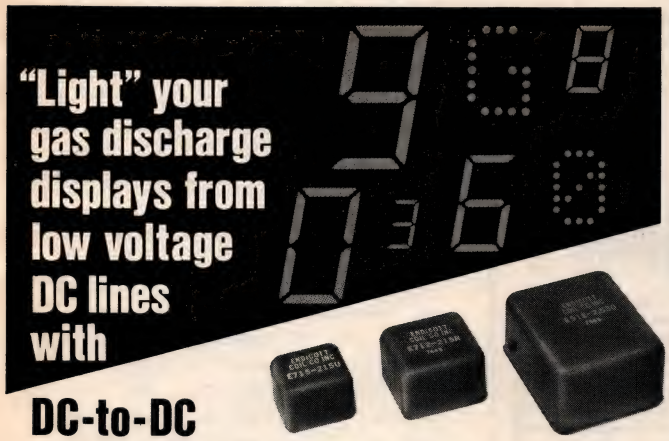
Circle No. 225

RELAYS. An extremely broad line of units is discussed in this catalog of time-delay relays. Contained in the 28-pg. brochure are application data, delay-function descriptions, selection guides and dimension drawings. Complete specs are given for solid-state hybrid, mercury-displacement, pc, thermal, dashpot and extended-delay type units. **Magnecraft Electric Co.,** 5575 N. Lynch Ave., Chicago, IL 60630.

Circle No. 226

PRINTERS. This 6-pg. document (which includes 8 photographs) lists specifications and functions, options and accessories, as well as mechanical and electrical characteristics of the Sprint Micro 3 family. The brochure also details features of the WideTrack model, the only character printer available with a 26-in. wide carriage/platen. **Qume,** 2323 Industrial Parkway W., Hayward, CA 94545.

Circle No. 227



"Light" your gas discharge displays from low voltage DC lines with

DC-to-DC Power Supplies

When you must convert low DC line voltages to nominal 200 or 250 V DC levels in order to activate gas discharge displays, ask us to recommend the DC-to-DC power supply that's right for your application.

Various models available:

- Standard inputs—5, 9, 12, 15 V DC; others under 5 V DC and up to 48 V DC.
- For seven-segment and matrix-type displays.
- Regulated and unregulated.
- Single and dual output, capable of up to 12 W total.
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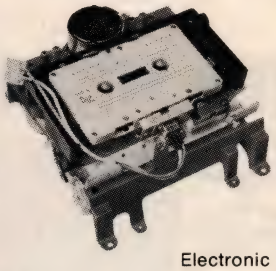
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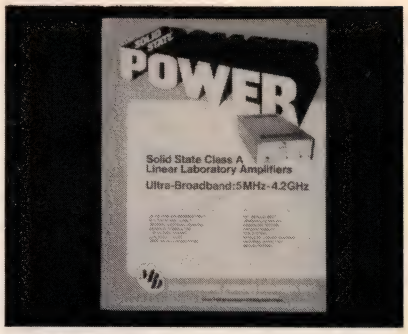
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LOGIC-STATE ANALYZERS. The 6-pg. AN 167-13 describes the role of these devices in the design of microprocessor-based systems. Intended for the reader familiar with basic logic-state analysis, it provides additional information on real-time problem solving, particularly regarding μP's. Included are sample display patterns, photographs, a flow chart, schematic diagrams and a bibliography. **Hewlett-Packard Co.,** 1501 Page Mill Rd., Palo Alto, CA 94304. **Circle No. 229**

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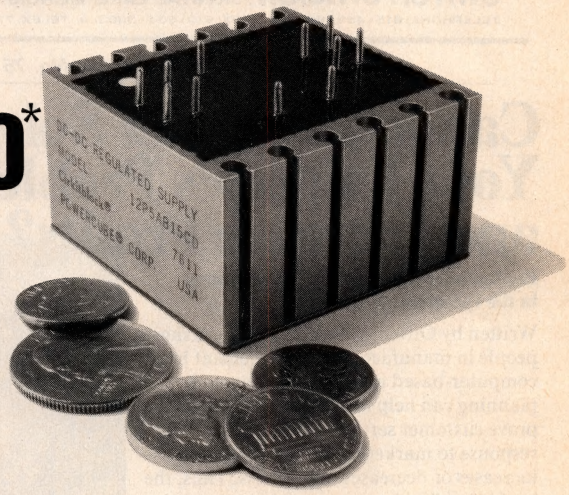
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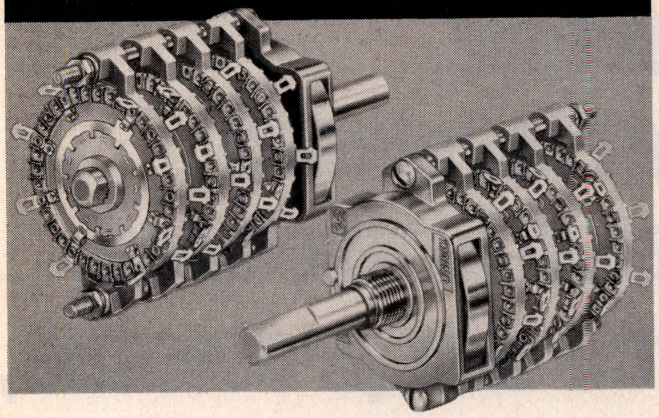
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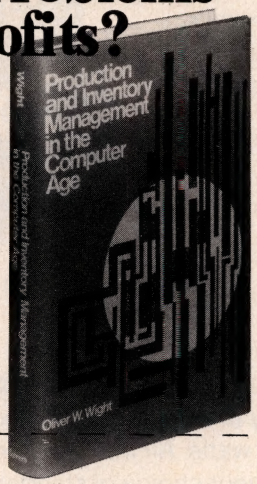
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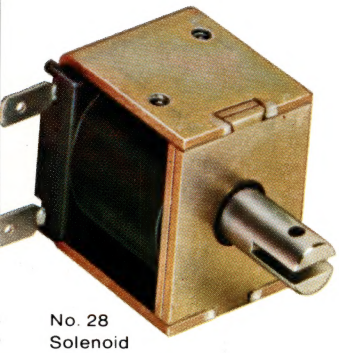
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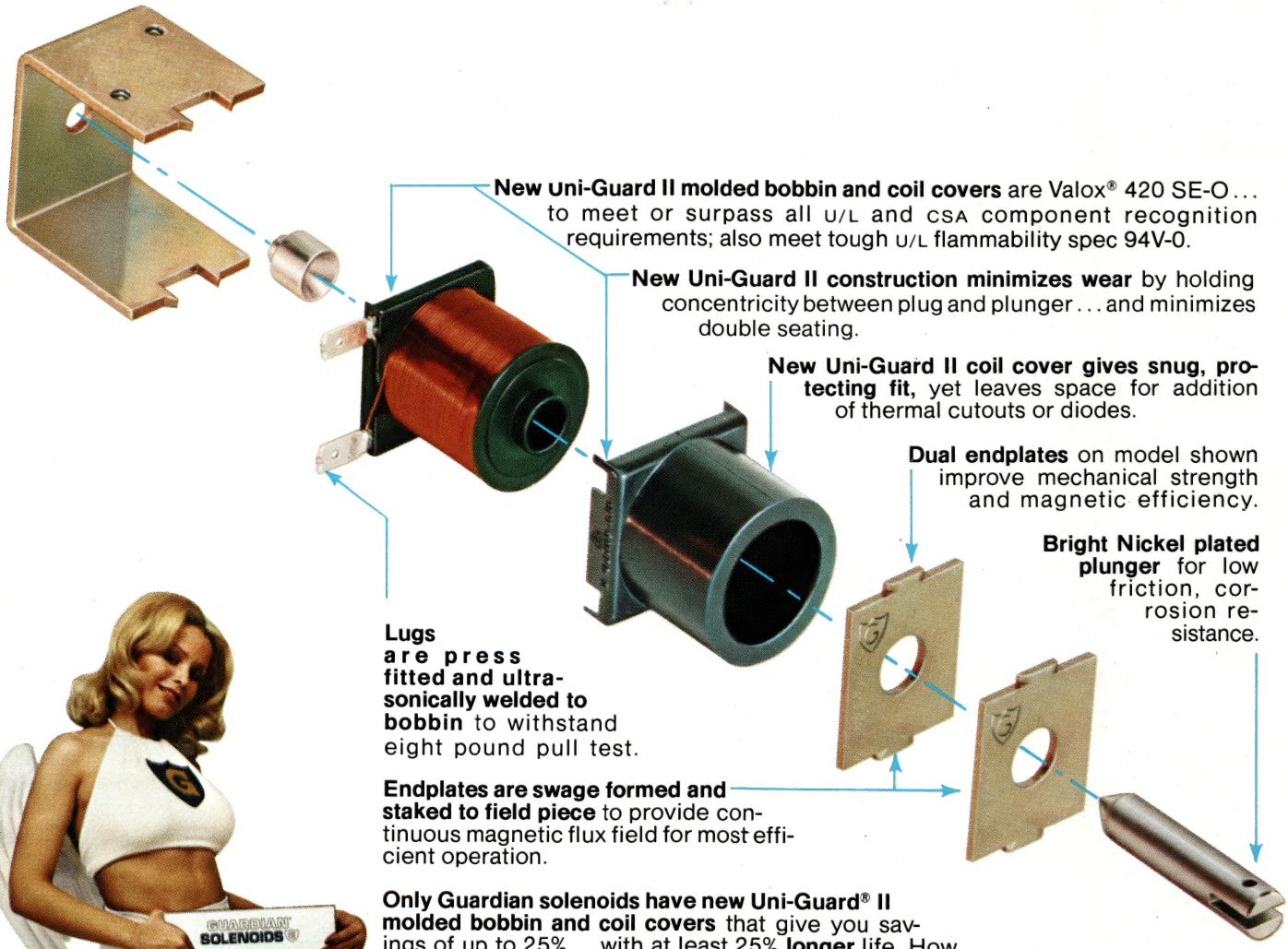
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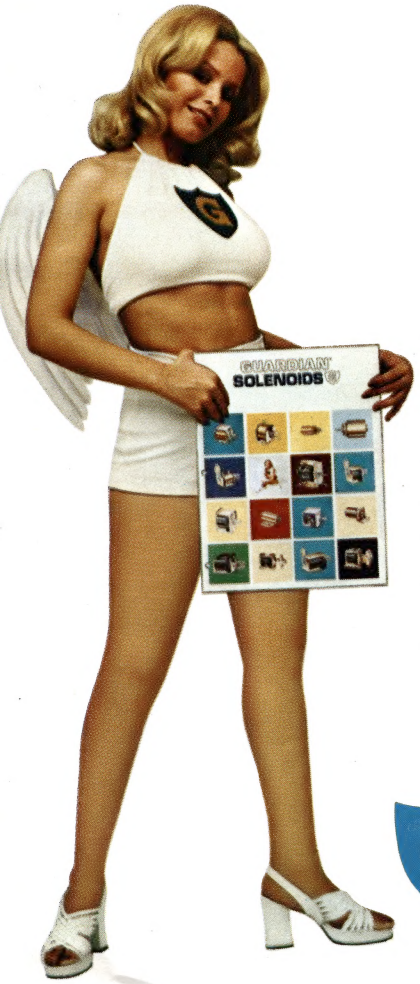
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